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Best Demonstrated Available Technology (BDAT) Background Document for K046 Nonreactive Subcategory

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BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
BACKGROUND DOCUMENT FOR
K046 NONREACTIVE SUBCATEGORY

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In promulgating treatment standards for K046 nonwastewaters, the Agency has established subcategories: nonreactive and reactive subcategories. Treatment standards for the reactive subcateogry of K046 nonwastewaters will be established at a later date.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in the K046 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization information that serves as the basis for determining whether variouances may be warranted for a particular waste that has the same waste code but has waste characteristics that make it more difficult.

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TABLE OF CONTENTS

Section Page

EXECUTIVE SUMMARY vii

1. INTRODUCTION 1-1

  1.1 Legal Background 1-1
    1.1.1 Requirements Under HSWA 1-1
    1.1.2 Schedule for Developing Restrictions ... 1-4
  1.2 Summary of Promulgated BDAT Methodology 1-5
    1.2.1 Waste Treatability Groups 1-7
    1.2.2 Demonstrated and Available Treatment Technologies 1-7
    1.2.3 Collection of Performance Data 1-11
    1.2.4 Hazardous Constituents Considered and Selected for Regulation 1-17
    1.2.5 Compliance with Performance Standards... 1-30
    1.2.6 Identification of BDAT 1-32
    1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes 1-36
    1.2.8 Transfer of Treatment Standards 1-40
  1.3 Variance from the BDAT Treatment Standard....... 1-41

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION 2-1

  2.1 Industry Affected and Process Description 2-1
  2.2 Waste Characterization.. 2-8

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES 3-1

  3.1 Applicable Treatment Technologies 3-1
  3.2 Demonstrated Treatment Technologies 3-2
  3.3 Detailed Description of Treatment Technologies.. 3-3
    3.3.1 Stabilization of Metals 3-3

4. PERFORMANCE DATA BASE 4-1

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) for K046.. 5-1

  5.1 Review of Performance Data 5-2
  5.2 Accuracy Correction of Performance Data 5-3
  5.3 Statistical Comparison of Performance Data 5-6
  5.4 BDAT for K046 Waste 5-7

TABLE OF CONTENTS (Continued)

Section Page

6. SELECTION OF REGULATED CONSTITUENTS 6-1

7. CALCULATION OF BDAT TREATMENT STANDARDS 7-1

    7.1 Editing the Data 7-1
    7.2 Correcting the Remaining Data 7-2
    7.3 Calculating the Variability Factors 7-3
    7.4 Calculating the Treatment Standards 7-5

8. ACKNOWLEDGMENTS 8-1

9. REFERENCES 9-1

APPENDIX A Statistical Methods A-1

APPENDIX B Analytical QA/QC B-1

APPENDIX C Detection Limits for Untreated and Treated K046 Wastes C-1

APPENDIX D Calculation of Treatment Standards.......... D-1

APPENDIX E Determination of Nonreactive and Reactive Forms of K046 .... E-1

LIST OF TABLES

Table | Page

1-1 BDAT CONSTITUENT LIST 1-18

2-1 FACILITIES PRODUCING K046 BY STATE 2-3

2-2 FACILITIES PRODUCING K046 BY EPA REGION 2-4

2-3 MAJOR CONSTITUENT COMPOSITION FOR K046 WASTE 2-9

2-4 BDAT CONSTITUENT COMPOSITION AND OTHER DATA 2-10

4-1 TREATMENT DATA FOR K046 STABILIZATION USING PORTLAND CEMENT 4-2

4-2 TREATMENT DATA FOR K046 STABILIZATION USING KILN DUST 4-3

4-3 TREATMENT DATA FOR K046 STABILIZATION USING LIME/FLYASH 4-4

5-1 TREATMENT DATA USED FOR REGULATION OF K046 WASTE ... 5-4

5-2 K046 NONWASTEWATER DATA SHOWING SUBSTANTIAL TREATMENT BY CEMENT STABILIZATION 5-8

6-1 BDAT LIST METALS DETECTED IN UNTREATED WASTE 6-2

7-1 REGULATED CONSTITUENTS AND CALCULATED TREATMENT STANDARDS FOR K046 NONWASTEWATERS 7-4

A-1 95TH PERCENTILE VALUES FOR THE F DISTRIBUTION....... A-2

B-1 ANALYTICAL METHODS B-2

B-2 SPECIFIC PROCEDURES OR EQUIPMENT USED IN PREPARATION AND ANALYSIS OF METALS WHEN ALTERNATIVES OR EQUIVALENTS ARE ALLOWED IN THE SW-846 METHODS B-3

B-3 MATRIX SPIKE FOR METALS FOR THE TCLP EXTRACT FOR THE CEMENT BINDER K046 .... B-4

LIST OF TABLES (Continued)

Table Page

B-4 MATRIX SPIKE FOR METALS FOR THE TCLP EXTRACT FOR THE KILN DUST K046 .... B-5

B-5 MATRIX SPIKE FOR METALS FOR THE TCLP EXTRACT FOR THE FLY ASH BINDER K046 .... B-6

C-1 DETECTION LIMITS FOR UNTREATED K046 .... C-2

C-2 DETECTION LIMITS FOR TREATED K046 .... C-3

LIST OF FIGURES

Figure | Page

2-1 FACILITIES PRODUCING K046 BY STATE AND EPA REGION 2-5

2-2 LEAD AZIDE MANUFACTURE 2-6

EXECUTIVE SUMMARY

BDAT Treatment Standards for K046

Pursuant to section 3004(m) of the Hazardous and Solid Waste Amendments (HSWA) enacted on November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed waste identified in 40 CFR 261.31 as K046. Compliance with these BDAT treatment standards is a prerequisite for placement of the waste in units designated as land disposal units according to 40 CFR Part 268. The effective date of these treatment standards is August 8, 1988.

In promulgating treatment standards for K046 nonwastewaters, the Agency has established two subcategories: Nonreactive Subcategory and Reactive Subcategory. For a protocol to determine whether a nonwastewater form of K046 is Nonreactive or Reactive, see Appendix E. In this background document, the promulgated treatment standards apply to the Nonreactive Subcategory of the K046 nonwastewaters. Treatment standards for the Reactive Subcategory of K046 nonwastewaters will be established by the Agency at a later date. Until these treatment standards are established, K046 nonwastewaters in the Reactive Subcategory are restricted from land disposal according to the "soft hammer" provisions, as stated in the Preamble for this rule, Section III (c) 3.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in the K046 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization information that serves as the basis for determining whether variances may be warranted for a particular waste that has the same waste code but has waste characteristics that make it more difficult to treat than the waste upon which the BDAT treatment standards are based.

The introductory section, which appears verbatim in all the First Third background documents, summarizes the Agency's legal authority and promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the documents presents waste-specific information--the number and locations of facilities affected by the land disposal restrictions for the K046 waste, the waste-generating process, characterization data, the technologies used to treat the waste (or similar wastes), and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

According to 40 CFR 261.32, waste code K046, which is generated by the explosives industries, is listed as follows:

K046: Wastewater treatment sludges from the manufacturing, formulation, and loading of lead-based initiating compounds.

EPA has estimated that 62 facilities in the explosives industry are potential generators of the K046 waste. Generators of K046 waste generally fall under Standard Industrial Classification (SIC) Code 2892 (explosives).

Treatment standards are established for nonwastewater forms of K046. (For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Waste not meeting this definition must comply with the treatment standards for nonwastewaters.)

For K046 nonwastewater, the Agency is establishing a treatment standard for lead. The treatment standard is based on performance data from stabilization using a portland cement binder. The Agency has not collected performance data for wastewater forms of K046, and treatment standards for K046 wastewaters were not established. As a result, K046 wastewaters are restricted from land disposal according to the "soft hammer" provisions, as stated in the Preamble, for this rule, Section III (c) 3.

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* The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by method 209c (Total Suspended Solids Dried at 103-105°C) in Standard Methods for the Examination of Water and Wastewater, 16th edition.

The following table presents the treatment standard for K046 waste. The treatment standard for K046 nonwastewaters reflects the concentration of constituents in the leachate from the Toxicity Characteristic Leaching Procedure (TCLP) and the units are mg/l (parts per million on a weight-by-volume basis). If the concentration of the regulated constituent in K046 waste, as generated, is lower than or equal to the proposed BDAT treatment standard, then treatment is not necessary as a prerequisite to land disposal.

Testing procedures are specifically identified in Appendix B of this background document.

BDAT Treatment Standards for K046
Nonreactive Subcategory

	Maximum for any single grab sample		
	Nonwastewater		Wastewater[a]
Constituent	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
Lead	NA	0.18	

NA = Not applicable.

[a] EPA intends to propose and promulgate numerical treatment standards for K046 wastewaters prior to May 8, 1990.

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the best demonstrated available technology (BDAT) treatment standards were developed, a summary of EPA's promulgated methodology for developing the BDAT treatment standards, and, finally, a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that satisfy such levels or methods of treatment established by EPA, i.e., treatment standards, are not prohibited from being land disposed.

In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters. Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, a particular constituent present in the wastes can be treated to the same concentration in all the wastes.

In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the amendments allow the Agency to grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set treatment standards by the statutory deadline for any hazardous waste in the First Third or Second Third waste groups (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets treatment standards for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set treatment standards for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvent and dioxin wastes by November 8, 1986;
2. The "California List" wastes by July 8, 1987;
3. At least one-third of all listed hazardous wastes by August 8, 1988 (First Third);

4. At least two-thirds of all listed hazardous wastes by June 8, 1989 (Second Third); and

5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish treatment standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third land disposal restriction rules. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m).

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than to require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that hazardous constituents in wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the wastes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one of the wastes in the group, the waste from which treatment standards are to be developed, is expected to be most difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are currently used on a full-scale basis to treat the waste of interest or a waste judged to be similar (see 51 FR 40588, November 7, 1986). EPA also will consider as demonstrated treatment those technologies used to separate or otherwise process chemicals and other materials on a full-scale basis. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. (The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document.) If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no full-scale treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste. Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also "available." To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste. These criteria are discussed below.

1. Commercially available treatment. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

2. Substantial treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern (provided the nondetectable levels are low relative to the concentrations in the untreated waste). If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

   - Number and types of constituents treated;

   - Performance (concentration of the constituents in the treatment residuals); and

   - Percent of constituents removed.

EPA will only set treatment standards based on a technology that meets both availability criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best demonstrated technology is unavailable, the treatment standards will be based on the next best demonstrated treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become available.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are considered in determining BDAT. The data evaluation includes data already collected directly by

EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (1) the identification of facilities for site visits, (2) the engineering site visit, (3) the sampling and analysis plan, (4) the sampling visit, and (5) the onsite engineering report.

(1) Identification of facilities for site visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities (TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using full-scale treatment systems. If performance data from properly designed and operated full-scale systems treating a particular waste or a waste judged to be similar are not available, EPA may use data from research facility operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering site visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to

ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and analysis plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific sampling and analysis plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency

of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific SAP within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of BDAT treatment standards. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up onsite engineering report.

(5) Onsite engineering report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the onsite engineering report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes that appear in Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986.

After the OER is completed, the report is submitted to the waste generator and/or treater for review. This review provides a final opportunity for claiming any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT list. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a

Table 1-1 BDAT Constituent List

BDAT reference no.	Constituent	CAS no.
	Volatile organics	
222.	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110-75-8
14.	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19.	Dibromomethane	74-95-3
20.	trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22.	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	trans-1,2-Dichloroethene	156-60-5
26.	1,2-Dichloropropane	78-87-5
27.	trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29.	1,4-Dioxane	123-91-1
224.	2-Ethoxyethanol	110-80-5
225.	Ethyl acetate	141-78-6
226.	Ethyl benzene	100-41-4
30.	Ethyl cyanide	107-12-0
227.	Ethyl ether	60-29-7
31.	Ethyl methacrylate	97-63-2
214.	Ethylene oxide	75-21-8
32.	Iodomethane	74-88-4
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78-93-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Volatile organics (continued)	
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4 Xylene	106-44-5
	Semivolatile organics	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4

Table 1-1 (Continued)

BDAT reference no	Constituent	CAS no.
	Semivolatile organics (continued)	
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	N-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3

Table 1 1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36 0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-3
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440 22 4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics other than metals	
169.	Cyanide	57 12 5
170.	Fluoride	16964-48 8
171.	Sulfide	8496-25-8
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319 86 8

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Organochlorine pesticides (continued)	
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202.	Aroclor 1232	11141-16-5
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") in March 1987. Additional constituents are added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. A waste can be listed as a toxic waste on the basis that it contains a constituent in Appendix VIII.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT constituent list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water, and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.

4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high performance liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is usually not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and the other inorganics, by using the same analytical methods.

(2) Constituent selection analysis. The constituents that the Agency selects for regulation in each waste are, in general, those found in the untreated wastes at treatable concentrations. For certain waste

codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to develop of list of potentially regulated constituents by summarizing all the constituents that are present or are likely to be present in the untreated waste at treatable concentrations. A constituent is considered present in a waste if the constituent (1) is detected in the untreated waste above the detection limit, (2) is detected in any of the treated residuals above the detection limit, or (3) is likely to be present based on the Agency's analyses of the waste-generating process. In case (2), the presence of other constituents in the untreated waste may interfere with the quantification of the constituent of concern, making the detection limit relatively high and resulting in a finding of "not detected" when, in fact, the constituent is present in the waste. Thus, the Agency reserves the right to regulate such constituents.

After developing a list of potential constituents for regulation, EPA reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents on the list. This indicator analysis is done for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6 of this background document.

(3) Calculation of standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average accuracy-corrected treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard for each constituent of concern is calculated by first averaging the mean performance value for each technology and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the technologies used as the basis for the BDAT treatment standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

Usually the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these numerical standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standards is prohibited, wastes that are generated in such a way as to naturally meet the standards can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal or that specify use of certain treatment methods, all established treatment standards are expressed as concentration levels.

EPA is using both the total constituent concentration and the concentration of the constituent in the TCLP extract of the treated waste as a measure of technology performance.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA is using this measurement because most technologies for treatment of organics destroy or remove organics compounds. Accordingly, the best measure of performance would be the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP extract value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals, and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP extract concentration as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is that it reduces the amount of metal in a waste by separating the metal for recovery; total constituent concentration in the treated residual, therefore, is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP extract concentration as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total and the TCLP extract constituent concentrations prior to land disposing the waste.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP value as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

BDAT for a waste must be the "best" of the demonstrated available technologies. EPA determines which technology constitutes "best" after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each demonstrated technology to that of the others. If only one technology is identified as demonstrated, it is considered "best"; if it is available, the technology is BDAT.

(1) Screening of treatment data. The first activity in determining which of the treatment technologies represent treatment by BDAT is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for the waste code(s) of interest are discussed in Section 3.2 of this document.)

2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the true value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP extract concentration for metals from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to use the data as a basis for the treatment standards. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern.

(2) Comparison of treatment data. In cases in which EPA has treatment data from more than one demonstrated available technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If EPA finds that one technology performs significantly better (i.e., is "best"), BDAT treatment standards

are the level of performance achieved by that best technology multiplied by the corresponding variability factor for each regulated constituent. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the technologies.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011.

To calculate the treatment standards for the land disposal restriction rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking--which is the addition of a known amount of the constituent--minus the initial concentration in the samples, all divided by the spike amount added) for each spiked sample of the treated residual. Once the recovery values are determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

2. If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (1) above.

3. If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spike sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by using the lowest average value.

4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is similar (e.g., if the data represent an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition methods, the specific procedures and equipment used are documented. In addition, any deviations from the SW-846, Third Edition methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from treatment trains generating multiple residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all derived-from wastes meeting the Agency definition of wastewater (less than 1 percent total organic carbon (TOC) and less than 1 percent total suspended solids) would have to meet the treatment standard for wastewaters. All residuals not meeting this definition would have to meet the treatment standard for nonwastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and other derived-from residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR 261.3(c)(2)(i)) or the mixture rule (40 CFR 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from managing listed wastes or that contain listed wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the listed hazardous waste as originally generated. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the original listed waste. Consequently, these residues are treated as the original listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain or from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology on the specific waste subject to the treatment standard. The Agency has determined that the constituents present in the untested waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance data for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries or processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether constituents in the untested wastes can be treated to the same level of performance as in the tested waste. First, EPA reviews the available waste characterization data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for the given waste(s) in Section 3.

Second, when analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste can be treated as well or better than the tested waste, the treatment standards can be transferred.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

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The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.
2. A statement of the petitioner's interest in the proposed action.
3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.
4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.
5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)
6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)
7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question: and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.
8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3 for a discussion of

waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.
10. A description of the methodologies and equipment used to obtain representative samples.
11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.
12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the Federal Register, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the Federal Register as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

The previous section provided the background for the Agency's study of K046 waste. The purpose of this section is to describe the industry that will be affected by land disposal restrictions on waste code K046 and to characterize this waste. This section includes a description of the industry affected and the production processes employed in this industry. Also included is a discussion of how K046 wastes are generated by these processes. The section concludes with a characterization of the K046 waste streams and a determination of the waste treatability group for this waste.

The complete list of hazardous waste codes from specific sources is given in 40 CFR 261.32 (see discussion in Section 1 of this document). Within this list, four specific hazardous waste codes are generated by the explosives industry. One of these is the listed waste K046.

2.1 Industry Affected and Process Description

According to 40 CFR 261.32 (hazardous wastes from specific sources), waste code K046 is specifically generated from the manufacture, formulation, and loading of lead-based initiating compounds. This waste is listed as follows:

K046: Wastewater treatment sludges from the manufacturing, formulation, and loading of lead-based initiating compounds.

The four-digit standard industrial classification (SIC) code reported for the explosives industry is 2892 and includes both commercial firms and government-owned plants operated by private firms.

The Agency estimates that 62 facilities in the United States are actively involved in the manufacture, formulation, and loading of lead-based initiating compounds and could generate K046 waste. Information from EPA's Hazardous Waste Data Management System (HWDMS) data base provides a geographic distribution of the number of these facilities across the United States.

Tables 2-1 and 2-2 present the location of those facilities that may generate waste code K046 in each State and EPA region. As can be seen in Tables 2-1 and 2-2, these facilities are concentrated in EPA Regions II, III, V, and VI. Figure 2-1 illustrates these data plotted on a map of the United States. Initiating compounds are generally organic- or lead-based. The major organic-based initiating compounds are tetracene, trinitroresorcinol (TNR), tetry, and nitromannite. The major lead-based initiating compounds are lead azide, lead styphnate, and lead mononitroresorcinate (LMR).

One manufacturing process for the production of lead azide is presented below. The listed waste K046 is generated in the production of lead azide, as well as in other processes. As shown in Figure 2-2, reacting lead nitrate or lead acetate with sodium azide produces lead azide. The reaction takes place in a precipitator where the lead azide product is precipitated and separated from the reaction by-products. The precipitate, consisting mainly of lead azide, is washed with water to remove any traces of impurities and is removed from the washer as the lead azide product. The wash water (wastewater) is then further treated and discharged.

Table 2-1 Facilities Producing K046 by State

State (EPA Region)	Number of facilities
Arkansas (IV)	2
California (IX)	4
Colorado (VIII)	1
Connecticut (I)	1
Idaho (X)	3
Illinois (V)	3
Indiana (V)	2
Iowa (VII)	1
Louisiana (VI)	5
Maryland (III)	2
Massachusetts (I)	1
Michigan (V)	2
Minnesota (IV)	2
Missouri (VII)	2
New Jersey (II)	5
New York (II)	3
North Carolina (IV)	1
Ohio (V)	4
Oregon (X)	1
Pennsylvania (III)	3
Texas (VI)	9
Virginia (III)	2
West Virginia (III)	1
Wisconsin (V)	1
Puerto Rico (II)	1
	Total 62

Reference: HWDMS, January 1986.

Table 2-2 Facilities Producing K046 by EPA Region

EPA Region	Number of facilities
I	2
II	9
III	8
IV	1
V	14
VI	16
VII	3
VIII	1
IX	4
X	4
Total	62

Reference: HWDMS, January 1986.

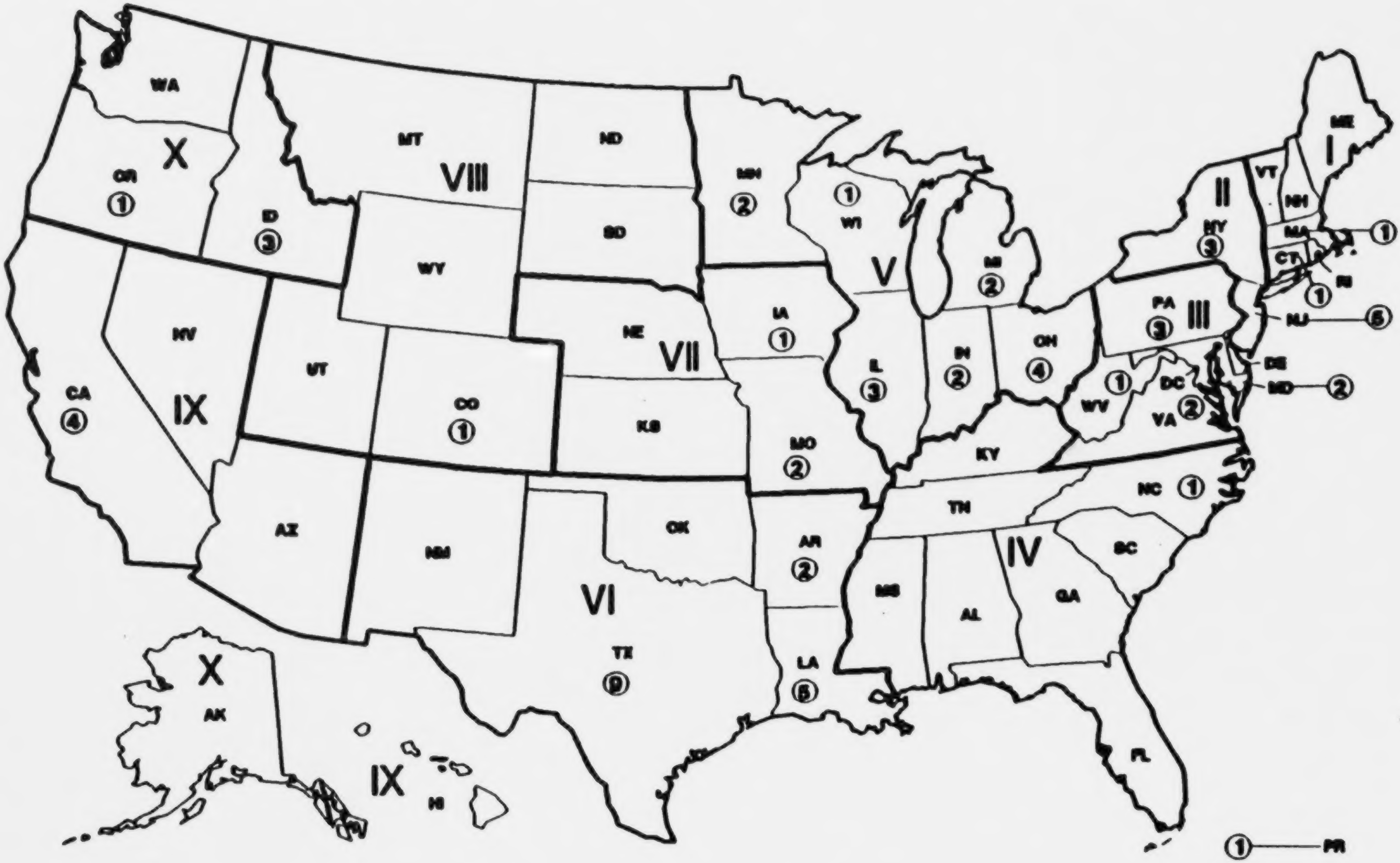
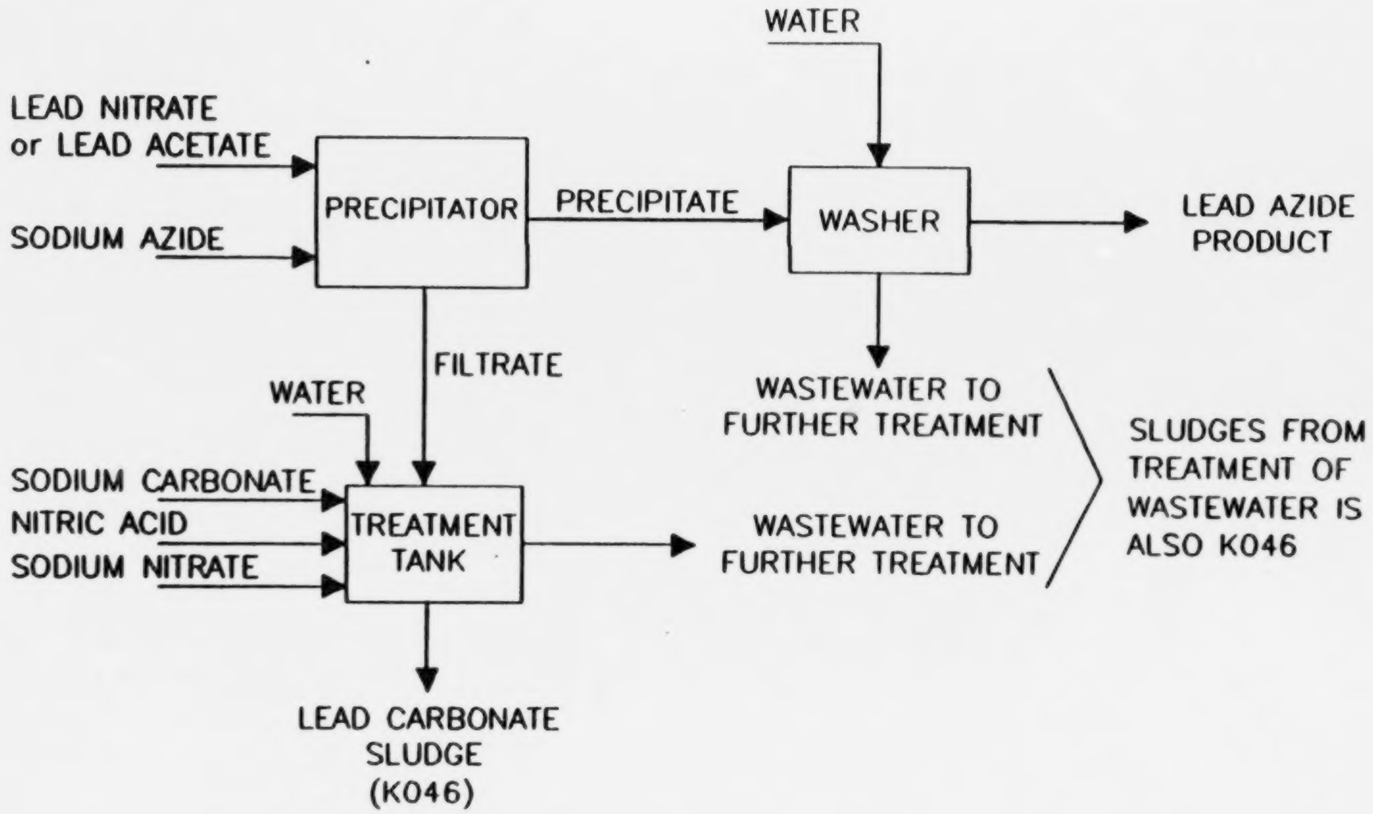

WA
OR ①
X
ID ③
MT
VIII
WY
ND
SD
NE
VII
KS
MN ②
IA ①
MO ②
WI ①
V
MI ②
IL ③
IN ②
OH ④
II
NY ③
VT
NH
ME
I
MA ①
CT
RI ①
PA ③
III
NJ ⑤
DE
MD ②
DC
WV ①
VA ②
KY
NC ①
TN
SC
IV
GA
AL
MS
FL
CA ④
NV
IX
UT
CO ①
AZ
NM
OK
VI
TX ⑨
AR ②
LA ⑤
X
AK
IX
HI
① PR

Figure 2-1 Facilities Producing K046 by State and by EPA Region


WATER
LEAD NITRATE or LEAD ACETATE
SODIUM AZIDE
PRECIPITATOR
PRECIPITATE
WASHER
LEAD AZIDE PRODUCT
FILTRATE
WATER
WASTEWATER TO FURTHER TREATMENT
SODIUM CARBONATE
NITRIC ACID
SODIUM NITRATE
TREATMENT TANK
WASTEWATER TO FURTHER TREATMENT
SLUDGES FROM TREATMENT OF WASTEWATER IS ALSO K046
LEAD CARBONATE SLUDGE (K046)

Reference: USEPA Effluent Guidelines Division, Office of Water and Hazardous Materials, Washington, D. C. EPA No. 440/176-060. March 1976.

JEG REV.1 MAR. 26, 1988

Figure 2-2 Lead Azide Manufacture

The filtrate from the precipitator goes to a treatment tank where chemicals are added to chemically transform traces of lead azide into a mixture of lead carbonate and lead nitrate. Sodium carbonate, sodium nitrite, and nitric acid are generally used as treatment chemicals in the treatment tank. Water is also added to the treatment tank to wash the filtrate stream from the precipitator. The sludge from the treatment tank is removed and sent to disposal or further treatment. This is the listed waste K046. The wastewater from the treatment tank is further treated and discharged. Sludges from the treatment of these wastewaters also constitute K046 waste.

The listed waste K046 is generated in the production of initiating compounds such as lead azide. In the production of lead azide, K046 is generated at the treatment tank. The filtrate (wastewater) from the precipitator flows to the treatment tank where chemicals such as nitric acid, sodium nitrite, and sodium carbonate are added to chemically transform lead azide in the wastewater to a mixture of lead nitrate and lead carbonate. A sludge, consisting mainly of lead carbonate and other insoluble lead salts, is formed in the treatment tank. This sludge, which is the listed waste K046, is removed from the treatment tank and sent to disposal.

Wastewater treatment sludges are also generated in the manufacture and processing of other lead-based initiators, such as lead styphnate and lead mononitroresorcinate (LMR). The Agency has no data regarding the physical and chemical characteristics of the wastewater treatment sludges generated by these processes. However, the Agency has no reason to believe that the wastewater treatment sludges generated by these processes are different, for the purpose of treatment, from the K046 waste generated by lead azide production. Therefore, the Agency will use the K046 waste generated by lead azide manufacture to represent the wastewater treatment sludges generated by the above processes.

2.2 Waste Characterization

This section includes all waste characterization data available to the Agency for the K046 waste treatability group. The major constituents that comprise this waste and an estimate of their approximate concentrations are presented in Table 2-3. The percent concentration of each major constituent in the waste was determined from best estimates based on chemical analyses. Table 2-3 shows that the major constituent in K046 is water (95 percent). The primary BDAT list metal constituent present in K046 is lead.

The ranges of BDAT list constituents present in the waste and all other available data concerning parameters affecting treatment selection are presented in Table 2-4. This table lists the levels of BDAT list metals present in K046 waste. Other parameters analyzed in the waste are also given (sulfate, sulfide, total oil and grease, pH, and total organic carbon).

Familiarization samples of K046 were taken by the Agency prior to the sampling visit. No BDAT list organics were detected in these samples. Tables 2-3 and 2-4 together provide a thorough characterization of the K046 waste.

Table 2-3 Major Constituent Composition for K046 Waste[a]

K046 Waste	
Constituent	Concentration (wt. percent)
Water	95
Lead	<1
Other BDAT List Metals	<1
Sodium Sulfide/Sodium Hydroxide	>3
TOTAL	100

[a] Percent concentrations presented here were determined based on chemical analyses.

TABLE 2-4 BDAT CONSTITUENT COMPOSITION AND OTHER DATA

BDAT CONSTITUENTS	DETECTION LIMIT	UNTREATED WASTE K046* TOTAL	TCLP
Metals (mg/l)			
154 Antimony	0.02	0.022	ND
155 Arsenic	0.01	ND	ND
156 Barium	0.2	ND	0.228
157 Beryllium	0.005	ND	ND
158 Cadmium	0.01	ND	ND
159 Chromium	0.02	ND	ND
160 Copper	0.025	ND	ND
161 Lead	0.01	967	103
162 Mercury	0.0003	0.00084	ND
163 Nickel	0.04	ND	ND
164 Selenium	0.005	ND	ND
165 Silver	0.05	ND	ND
166 Thallium	0.01	ND	ND
167 Vanadium	0.05	ND	ND
168 Zinc	0.05	0.295	0.335
Other Parameters (mg/l)			
Sulfate	2	190	NA
Sulfide	1	ND	NA
Oil & Grease		3.8	NA
Total Organic Carbon (Avg.)		461	NA
pH		11.91	NA

* - Values obtained from Onsite Engineering Report for K046 (Waterways Experiment Station).

NA - Not analyzed.

ND - Not detected.

Note: Only one sample of K046 was analyzed. Total organic carbon results are an average of four analyses on the same sample.

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

The previous section described the industry that will be affected by restrictions on K046 waste and presented a characterization of this waste. The purpose of this section is to describe treatment technologies for K046 waste that EPA has identified as applicable, and to describe which of the applicable technologies EPA has determined to be demonstrated.

3.1 Applicable Treatment Technologies

Familiarization samples taken by EPA prior to the sampling visit showed that K046 waste consists primarily of water, with BDAT list metals present at treatable concentrations and BDAT list organics present at untreatable (de minimis) concentrations. Because the levels of BDAT list metals were treatable while the levels of BDAT list organics were untreatable, the treatment technologies considered applicable for treatment of K046 waste are those that treat BDAT list metals. No treatment for BDAT list organics is required.

The EPA has therefore identified the following applicable technology for treatment of K046 waste: stabilization using various binder materials (cement, kiln dust, and lime/flyash). Metals recovery is not judged to be an applicable technology because of the relatively low metal concentrations present.

Analysis of the K046 sludge indicates that it consists mainly of water (95 percent). BDAT constituents constitute less than 2 percent and non-BDAT constituents (sodium sulfide and sodium hydroxide) constitute greater than 3 percent of the K046 waste. Of the BDAT list metals present, lead is present in the highest concentration. The selection of the treatment technologies applicable for stabilizing metal constituents in K046 waste is based on available literature sources (see References) and field testing.

For K046 waste, the Agency has identified the following stabilization technologies as being applicable: cement-based processes, which use cement binder additives to chemically bind the metal constituents in a solidified waste matrix; lime-based processes, which use lime and other additives to chemically bind the metal constituents in a solidified waste matrix; and kiln dust (or pozzolan) processes, which use flyash from cement kilns and lime to chemically bind metal components in a solidified waste matrix.

3.2 Demonstrated Treatment Technologies

The Agency believes that none of the above applicable technologies are currently in commercial use for treating K046 waste. The Agency therefore decided to collect performance data for treatment systems that are demonstrated commercially for wastes similar to K046 (in terms of parameters affecting treatment selection).

The following three stabilization processes were tested by the Agency:

- Cement-based process;
- Kiln dust process; and
- Lime/flyash process.

EPA chose to collect performance data for these three stabilization systems because these systems are currently being used to stabilize wastes similar to K046 (in terms of parameters affecting treatment selection) on a commercial basis. A more detailed discussion of these treatment technology systems follows.

3.3 Detailed Description of Treatment Technologies

3.3.1 Stabilization of Metals

Stabilization refers to a broad class of treatment processes that chemically reduce the mobility of hazardous constituents in a waste. Solidification and fixation are other terms that are sometimes used synonymously for stabilization or to describe specific variations within the broader class of stabilization. Related technologies are encapsulation and thermoplastic binding; however, EPA considers these technologies to be distinct from stabilization in that the operational principles are significantly different.

(1) Applicability and use of stabilization. Stabilization is used when a waste contains metals that will leach from the waste when it is contacted by water or a mild acid solution. In general, this technology is applicable to wastes containing BDAT list metals and that have a high filterable solids content, low TOC content, and low oil and grease content. This technology is commonly used to treat residuals generated from treatment of metallic wastewaters such as those produced by electroplating.

(2) Underlying principles of operation. The basic principle underlying this technology is that the stabilizing agent and other chemicals are added to a waste to minimize the amount of metal that

leaches. The reduced leachability is accomplished by the formation of a lattice structure and/or chemical bonds that bind the metals to the solid matrix and thereby limit the amount of metal constituents that can be leached when water or a mild acid solution comes into contact with the stabilized material.

There are two principal stabilization processes used; these are cement based and lime based. A brief discussion of each is provided below. In both cement-based or lime/pozzolan-based techniques, the stabilizing process can be modified through the use of additives, such as silicates, that control curing rates or enhance the properties of the solid material.

(a) Portland cement-based process. Portland cement is a mixture of powdered oxides of calcium, silica, aluminum, and iron, produced by kiln burning of material rich in calcium and silica at high temperatures (i.e., 1400 to 1500°C). When the anhydrous cement powder is mixed with water, hydration occurs and the cement begins to set. The chemistry involved is complex because many different reactions occur depending on the composition of the cement mixture.

As the cement begins to set, a colloidal gel of indefinite composition and structure is formed. Over time, the gel swells and forms a matrix composed of interlacing, thin, densely packed silicate fibrils. Constituents present in the waste slurry (e.g., hydroxides and carbonates of various heavy metals) are incorporated into the interstices of the cement matrix. The high pH of the cement mixture tends to keep metals in the form of insoluble hydroxide and carbonate salts. It has been hypothesized that metal ions may also be incorporated into the crystal structure of the cement matrix, but this hypothesis has not been verified.

(b) Lime/pozzolan-based process. Pozzolan, which contains finely divided, noncrystalline silica (e.g., flyash or components of cement kiln dust), is a material that is not cementitious in itself, but becomes so upon the addition of lime. Metals in the waste are converted to silicates or hydroxides, which inhibit leaching. Additives, again, can be used to reduce permeability and, as a result, further decrease leaching potential.

(3) Description of stabilization processes. In most stabilization processes, the waste, stabilizing agent, and other additives, if used, are mixed and then pumped to a curing vessel or area and allowed to cure. The actual operation (equipment requirements and process sequencing) will depend on several factors such as the nature of the waste, the quantity of the waste, the location of the waste in relation to the disposal site, the particular stabilization formulation to be used, and the curing rate. After curing, the solid formed is removed from the processing equipment and shipped for final disposal.

Waste to be treated, which is contained in lagoons or surface impoundments and which has a high water content, should first be dewatered. The dewatered material or waste not needing dewatering should then be transferred to mixing vessels where stabilizing agents are added. The mixed material is then fed to a curing pad or vessel. After curing, the solid formed is removed for disposal. Equipment commonly used also includes facilities to store waste and chemical additives. Pumps can be used to transfer liquid or light sludge wastes to the mixing pits and pumpable uncured wastes to the curing site. Stabilized wastes are then removed to a final disposal site.

Commercial concrete mixing and handling equipment generally can be used with wastes. Weighing conveyors, metering cement hoppers, and mixers similar to concrete batching plants have been adapted in some operations. Where extremely dangerous materials are being treated, remote-control and in-drum mixing equipment, such as that used with nuclear waste, can be employed.

(4) Waste characteristics affecting performance. In determining whether stabilization is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the Agency will focus on the characteristics that inhibit the formation of either the chemical bonds or the lattice structure. The four characteristics EPA has identified as affecting treatment performance are the presence of (1) fine particulates, (2) oil and grease, (3) organic compounds, and (4) certain inorganic compounds.

(a) Fine particulates. For both cement-based and lime/pozzolan-based processes, the literature states that very fine solid materials (i.e., those that pass through a No. 200 mesh sieve, 74 um particle size) can weaken the bonding between waste particles and cement by coating the particles. This coating can inhibit chemical bond formation and thereby decreases the resistance of the material to leaching.

(b) Oil and grease. The presence of oil and grease in both cement-based and lime/pozzolan-based systems results in the coating of waste particles and the weakening of the bonding between the particle and the stabilizing agent. This coating can inhibit chemical bond formation and thereby decrease the resistance of the material to leaching.

(c) Organic compounds. The presence of organic compounds in the waste interferes with the chemical reactions and bond formation that inhibit curing of the stabilized material. This results in a stabilized waste having decreased resistance to leaching.

(d) Sulfate and chlorides. The presence of certain inorganic compounds will interfere with the chemical reactions, weakening bond strength and prolonging setting and curing time. Sulfate and chloride compounds may reduce the dimensional stability of the cured matrix, increasing leaching potential.

Accordingly, EPA will examine these constituents when making decisions regarding transfer of treatment standards based on stabilization.

(5) Design and operating parameters. In designing a stabilization system, the principal parameters that are important to optimize so that the amount of leachable metal constituents is minimized are: (1) selection of stabilizing agents and other additives, (2) ratio of

waste to stabilizing agents and other additives, (3) degree of mixing, and (4) curing conditions.

(a) Selection of stabilizing agents and other additives. The stabilizing agent and additives used will determine the chemistry and structure of the stabilized material and thus will affect the leachability of the solid material. Stabilizing agents and additives must be carefully selected based on the chemical and physical characteristics of the waste to be stabilized. For example, the amount of sulfates in a waste must be considered when a choice is being made between a lime/pozzolan- and a portland cement-based system.

To select the type of stabilizing agents and additives, the waste should be tested in the laboratory with a variety of materials to determine the best combination.

(b) Amount of stabilizing agents and additives. The amount of stabilizing agents and proprietary additives is a critical parameter since there must be enough stabilizing materials in the mixture to bind the waste constituents of concern properly, making them less susceptible to leaching. The appropriate weight ratios of waste to stabilizing agent and other additives are established empirically by setting up a series of laboratory tests that allow separate leachate testing of different mix ratios. The ratio of water to stabilizing agent (including water in waste) will also impact the strength and leaching characteristics of the stabilized material. Too much water will cause low strength; too little will make mixing difficult and, more important, may not allow the chemical reactions that bind the hazardous constituents to be fully completed.

(c) Mixing. The conditions of mixing include the type and duration of mixing. Mixing is necessary to ensure homogeneous distribution of the waste and the stabilizing agents. Both undermixing and overmixing are undesirable. The first condition results in a nonhomogeneous mixture; therefore, areas will exist within the waste where waste particles are neither chemically bonded to the stabilizing agent nor physically held within the lattice structure. Overmixing, on the other hand, may inhibit gel formation and ion adsorption in some stabilization systems. As with the relative amounts of waste, stabilizing agent, and additives within the system, optimal mixing conditions generally are determined empirically through laboratory tests. During treatment it is important to monitor the degree (i.e., type and duration) of mixing to ensure that it reflects design conditions.

(d) Curing conditions. The curing conditions include the duration of curing and the ambient curing conditions (temperature and humidity). The duration of curing is a critical parameter to ensure that the waste particles have had sufficient time in which to form stable chemical bonds and/or lattice structures. The time necessary for complete stabilization depends upon the waste type and the stabilization used. The quality of the stabilized waste (i.e., the concentrations of constituents in the leachate) will be highly dependent upon whether complete stabilization has occurred. Higher temperatures and lower humidity increase the rate of curing by increasing the rate of evaporation of water from the solidification mixtures. If temperatures are too high, however, the evaporation rate can be excessive. This can result in too little water being available for completion of the chemical reactions associated with the stabilization process. The duration of the curing process should also be determined during the design stage and typically will be between 7 and 28 days.

4. PERFORMANCE DATA BASE

This section discusses all available performance data that EPA has amassed on the demonstrated technologies discussed in Section 3. Performance data include the untreated and treated waste concentrations for a given constituent, the operating values that existed at the time the waste was being treated, the design values for the treatment technology, and data on waste characteristics that affect treatment performance. EPA has provided all such data to the extent that they are available.

EPA's use of these data in determining the technology that represents BDAT and in the development of treatment standards is discussed in Sections 5 and 7, respectively.

For K046, EPA has performance data on stabilization using cement, kiln dust, and lime/flyash. These data are presented in Tables 4-1 to 4-3.

The untreated K046 waste and the treated (stabilized) K046 waste for each sample set were analyzed for BDAT metals, inorganics, and other parameters. Also included in Tables 4-1 through 4-3 are the design values and actual operating ranges for the key operating parameters of the cement, kiln dust, and lime/flyash processes.

TABLE 4-1 TREATMENT DATA FOR K046 STABILIZATION USING PORTLAND CEMENT

	UNTREATED WASTE		TREATED WASTE*		
BDAT CONSTITUENTS	TOTAL	TCLP	SS 1	SS 2	SS 3
Metals (mg/l)					
154 Antimony	0.022	ND	ND	ND	ND
155 Arsenic	ND	ND	ND	ND	ND
156 Barium	ND	0.228	1.8	1.8	1.8
157 Beryllium	ND	ND	ND	ND	ND
158 Cadmium	ND	ND	ND	ND	ND
159 Chromium	ND	ND	0.033	ND	0.03
160 Copper	ND	ND	ND	ND	0.019
161 Lead	967	103	0.072	0.1	0.062
162 Mercury	0.00084	ND	0.0003	ND	ND
163 Nickel	ND	ND	ND	ND	ND
164 Selenium	ND	ND	ND	ND	ND
165 Silver	ND	ND	ND	ND	ND
166 Thallium	ND	ND	ND	ND	ND
167 Vanadium	ND	ND	ND	ND	ND
168 Zinc	0.295	0.335	0.036	0.027	0.112
Other Parameters (mg/l)					
Sulfate	190	NA	NA	NA	NA
Sulfide	ND	NA	NA	NA	NA
Oil & Grease	3.8	NA	NA	NA	NA
Total Organic Carbon (Avg.)	461	NA	NA	NA	NA
pH	11.91	NA	NA	NA	NA

* - Treated waste data reflect analysis of TCLP extracts.

NA - Not analyzed.

ND - Not detected (see Appendix C for detection limits).

OPERATING PARAMETERS

Binder to Waste Ratio**	Run	Dry Waste + Water Weight (g)	Binder Weight (g)	Mixture pH (standard units)
1.2	A	600	720	12.35
1.2	B	600	720	12.35
1.2	C	600	720	12.35

** EPA checked the data and determined that the treated levels cannot be obtained solely by dilution (due to the high binder/waste ratios).

TABLE 4-2 TREATMENT DATA FOR K046 STABILIZATION USING KILN DUST

BDAT CONSTITUENTS	UNTREATED WASTE TOTAL	UNTREATED WASTE TCLP	TREATED WASTE* SS 1	TREATED WASTE* SS 2	TREATED WASTE* SS 3
Metals (mg/l)					
154 Antimony	0.022	ND	ND	ND	ND
155 Arsenic	ND	ND	ND	ND	ND
156 Barium	ND	0.228	0.3	0.4	0.3
157 Beryllium	ND	ND	ND	ND	ND
158 Cadmium	ND	ND	ND	ND	ND
159 Chromium	ND	ND	0.06	0.1	0.06
160 Copper	ND	ND	ND	0.1	ND
161 Lead	967	103	0.9	1.1	1
162 Mercury	0.00084	ND	ND	ND	ND
163 Nickel	ND	ND	ND	0.07	ND
164 Selenium	ND	ND	0.014	0.015	0.012
165 Silver	ND	ND	ND	ND	ND
166 Thallium	ND	ND	0.008	0.009	0.007
167 Vanadium	ND	ND	ND	ND	ND
168 Zinc	0.295	0.335	ND	ND	ND
Other Parameters (mg/l)					
Sulfate	190	NA	NA	NA	NA
Sulfide	ND	NA	NA	NA	NA
Oil & Grease	3.8	NA	NA	NA	NA
Total Organic Carbon (Avg.)	461	NA	NA	NA	NA
pH	11.91	NA	NA	NA	NA

* - Treated waste data reflect analysis of TCLP extracts.

NA - Not analyzed.

ND - Not detected (see Appendix C for detection limits).

OPERATING PARAMETERS

Binder to Waste Ratio**	Run	Dry Waste + Water Weight (g)	Binder Weight (g)	Mixture pH (standard units)
1.4	A	600	840	12.25
1.4	B	600	840	12.15
1.4	C	600	840	12.35

** EPA checked the data and determined that the treated levels cannot be obtained solely by dilution (due to the high binder/waste ratios).

TABLE 4-3 TREATMENT DATA FOR K046 STABILIZATION USING LIME/FLYASH

BDAT CONSTITUENTS	UNTREATED WASTE TOTAL	UNTREATED WASTE TCLP	TREATED WASTE* SS 1	TREATED WASTE* SS 2	TREATED WASTE* SS 3
Metals (mg/l) ------					
154 Antimony	0.022	ND	ND	ND	ND
155 Arsenic	ND	ND	ND	ND	ND
156 Barium	ND	0.228	3.7	3.5	3.5
157 Beryllium	ND	ND	ND	ND	ND
158 Cadmium	ND	ND	ND	ND	ND
159 Chromium	ND	ND	ND	ND	ND
160 Copper	ND	ND	0.008	ND	0.01
161 Lead	967	103	0.4	0.4	0.4
162 Mercury	0.00084	ND	ND	ND	ND
163 Nickel	ND	ND	ND	0.07	ND
164 Selenium	ND	ND	ND	ND	ND
165 Silver	ND	ND	ND	ND	ND
166 Thallium	ND	ND	0.001	0.002	0.002
167 Vanadium	ND	ND	ND	ND	ND
168 Zinc	0.295	0.335	0.04	ND	ND
Other Parameters (mg/l) -----					
Sulfate	190	NA	NA	NA	NA
Sulfide	ND	NA	NA	NA	NA
Oil & Grease	3.8	NA	NA	NA	NA
Total Organic Carbon (Avg.)	461	NA	NA	NA	NA
pH	11.91	NA	NA	NA	NA

* - Treated waste data reflect analysis of TCLP extracts.

NA - Not analyzed.

ND - Not detected (see Appendix C for detection limits).

OPERATING PARAMETERS

Lime to Waste Ratio	Flyash to Waste Ratio	Run	Dry Waste + Water Weight (g)	Lime Weight (g)	Flyash Weight (g)	Mixture pH (standard units)
0.7	0.7	A	600	420	420	12.25
0.7	0.7	B	600	420	420	12.15
0.7	0.7	C	600	420	420	12.35

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) for K046

The two previous sections described applicable treatment technologies for waste code K046 and the available performance data for these technologies. This section describes how the performance data collected by the Agency were evaluated to determine which treatment technology system should be considered BDAT for waste code K046. As discussed in detail in Section 1, this determination essentially involves determining which of the "demonstrated" technologies will provide the "best" treatment and, at the same time, be determined to be "available" (i.e., the technology can be purchased or licensed and provides substantial treatment). Three stabilization techniques are considered in this section in the selection of BDAT for K046 nonwastewater. These techniques are:

- Stabilization using a portland cement binder ,
- Stabilization using a kiln dust binder, and
- Stabilization using a lime/flyash binder.

As discussed in Section 4, the Agency collected performance data for the treatment of waste code K046 from these three stabilization systems.

No additional performance data were available for the treatment of K046 waste.

The topics covered in this section include descriptions of the data screening process employed for selecting BDAT, the methods used to ensure accuracy of the analytical data, and the analysis of variance (ANOVA) tests performed in identifying the best technology for the treatment of K046 waste.

In general, performance data are screened according to the following three conditions:

- Proper design and operation of the treatment system;
- The existence of quality assurance/quality control measures in the data analysis; and
- The use of proper analytical tests in assessing treatment performance.

Sets of performance data that do not meet these three conditions are not considered in the selection of BDAT. In addition, if performance data indicate that the treatment system was not well designed and well operated at the time of testing, these data also would not be used.

The remaining performance data are then corrected to account for incomplete recovery of certain constituents during the analyses. Finally, in cases where the Agency has adequate performance data for treatment of the waste by more than one technology, an analysis of variance (ANOVA) test is used to select the best treatment technology.

5.1 Review of Performance Data

In the selection of BDAT for treatment of K046 nonwastewater, the only performance data available were those collected during the Agency's sampling visit. Three data sets were collected by the Agency for treatment of the nonwastewater by stabilization using each of the following binder materials: portland cement, kiln dust, and lime/flyash. These data were evaluated to determine whether any of the data represented poor design or poor operation of the system. None of the data sets were deleted because of poor operation of the stabilization system during the time data were being collected. Therefore, all data sets were used in the selection of BDAT and the development of treatment standards for K046 nonwastewater.

Toxic Characteristic Leaching Procedure (TCLP) data were used in setting treatment standards for waste code K046, since BDAT list metals were present in the untreated waste at treatable levels. For a discussion on the use of TCLP data in setting treatment standards, refer to Section 1 of this background document.

In instances where a selected constituent was not detected in the treated waste, the treated value for that constituent was assumed to be the practical quantification level. This was the case for several of the BDAT list metal constituents. Analytical values for the BDAT list metals of concern in the treated waste are presented in Table 5-1. These numbers are taken from Tables 4-1 to 4-3 of this document.

5.2 Accuracy Correction of Performance Data

After the analytical data were screened as described above, the Agency adjusted the remaining data using analytical recovery values in order to take into account analytical interferences and incomplete recoveries associated with the chemical makeup of the sample. The Agency developed the recovery data (also referred to as accuracy data) by first analyzing a waste sample for a given constituent and then adding a known amount of the same constituent (i.e., spike) to the waste material. The total amount recovered after spiking, minus the initial concentration in

TABLE 5-1 Treatment Data Used for Regulation of K046 Waste

BDAT List Constituent	Analytical Concentrations[1]			Matrix Spike	Matrix Spike Duplicate	Accuracy Correction Factor	Accuracy-Corrected Concentrations[2]			
	SS 1 (TCLP) (mg/l)	SS 2 (TCLP) (mg/l)	SS 3 (TCLP) (mg/l)	(TCLP) (% recovery)	(TCLP) (% recovery)		SS 1 (TCLP) (mg/l)	SS 2 (TCLP) (mg/l)	SS 3 (TCLP) (mg/l)	Average (TCLP) (mg/l)
Cement:										
Barium	1.8	1.8	1.8	104	110	0.96	1.728	1.728	1.728	1.728
Lead	0.072	0.1	0.061	77.4	77.4	1.29	0.093	0.129	0.080	0.101
Zinc	0.036	0.027	0.112	96	98	1.04	0.038	0.028	0.117	0.061
Kiln Dust:										
Barium	0.3	0.4	0.3	108	106	0.94	0.282	0.376	0.282	0.313
Lead	0.9	1.1	0.68	90.5	94.5	1.10	0.994	1.215	1.105	1.105
Zinc	<0.02	<0.02	<0.02	69	72	1.45	0.029	0.029	0.029	0.029
Lime/Flyash										
Barium	3.7	3.5	3.5	99	84	1.19	4.140	4.165	4.165	4.157
Lead	0.4	0.4	0.56	69.5	77.2	1.44	0.576	0.576	0.576	0.576
Zinc	0.04	<0.02	<0.02	67	74	1.49	0.060	0.030	0.030	0.040

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1. Onsite Engineering Report for K046 (Waterways Experiment Station).
2. A sample calculation is shown in Appendix B of this Background Document.

the sample, divided by the amount added, is the recovery value. At least two recovery values were calculated for spiked constituents, and the analytical data were adjusted for accuracy using the lowest recovery value for each constituent.

Adjustment of the analytical data was accomplished by calculating an accuracy factor from the percent recoveries for each selected constituent. The reciprocal of the lower of the two recovery values, divided by 100, yields the accuracy factor. The corrected concentration for each sample set is obtained by multiplying the accuracy factor by the uncorrected data value. The actual recovery values for the selected constituents are presented in Table 5-1, along with the calculated accuracy factors.

The accuracy factors calculated for the selected constituents in K046 varied from a high value of 1.29 for lead to a low value of 0.96 for barium. The corrected concentration values for the selected constituents in the waste are shown for the three treatment systems in Table 5-1. These corrected concentration values were obtained by multiplying the accuracy factors by the uncorrected concentration values for the selected constituents in the treated waste. An arithmetic average value, representing the treated waste concentration, was calculated for each selected constituent from the three corrected values. These averages are presented in Table 5-1. These adjusted values for the three stabilization techniques tested were then used to determine BDAT for waste code K046.

5.3 Statistical Comparison of Performance Data

In cases where the Agency has adequate performance data on treatment of the same or similar wastes using more than one technology, an analysis of variance (ANOVA) test is performed to determine whether one of the technologies provides significantly better treatment than the others. In cases where a particular treatment technology is shown to provide the best treatment, the treatment standards will be based on this best technology. The procedure followed for the analysis of variance (ANOVA) test is described in Appendix A.

To determine BDAT for waste code K046, three demonstrated technologies, for which adequate performance data were available, were considered for the treatment of these wastes:

- Stabilzation using a portland cement binder,
- Stabilization using a kiln dust binder, and
- Stabilization using a lime/flyash binder.

The corrected data for all sample sets were used to perform analysis of variance (ANOVA) tests to compare these three stabilization technologies. The three treatment technologies were compared based on the concentration of primary waste constituent (lead) in the treated waste. The rationale for selecting this constituent for the ANOVA comparison is presented in Section 6. The ANOVA calculations are summarized in Appendix D.

The statistical results of the ANOVA test for K046 waste indicate that stabilization using a portland cement binder gives better treatment for lead in K046 than stabilization using a kiln dust or lime/flyash binder.

5.4 BDAT for K046 Waste

Stabilization using a portland cement binder provides significantly better or equivalent treatment overall for the primary constituents present in waste code K046 when compared to either stabilization using a kiln dust binder or stabilization using a lime/flyash binder. Therefore, the Agency determined stabilization using a portland cement binder to be BDAT for waste code K046.

Based on the water content of this waste, EPA recommends physical dewatering processes prior to stabilization to reduce the binder-to-waste ratio necessary to achieve effective stabilization of the waste. Stabilization is judged to be available to treat K046 nonwastewater. The Agency believes this technology to be available because (1) it is commercially available and (2) it provides a substantial reduction in the levels of BDAT list constituents present in K046 waste (see Table 5-2).

TABLE 5-2 K046 NONWASTEWATER DATA SHOWING SUBSTANTIAL TREATMENT BY CEMENT STABILIZATION

Constituent	UNTREATED WASTE Total Composition (mg/l)	TCLP (mg/l)	TREATED WASTE* Sample Set #1 (mg/l)	Sample Set #2 (mg/l)	Sample Set #3 (mg/l)
K046					
Lead	967	103	0.072	0.1	0.062

* - Treated waste data reflect analysis of TCLP extracts and corrected for accuracy.

6. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (Table 1-1) from which the constituents to be regulated are selected. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous insecticides, PCBs, and dioxins and furans.

This section describes the process used to select the constituents to be regulated for K046. The process involves developing a list of potential regulated constituents and then eliminating those constituents that would not be treated by the chosen BDAT or that would be controlled by regulation of the remaining constituents.

As discussed in Sections 2 and 4, the Agency has characterization data as well as performance data from treatment of K046. All these data, along with information on the waste-generating process, have been used to determine which BDAT list constituents may be present in the waste and thus which are potential candidates for regulation in K046 nonwastewater.

Table 6-1 shows which constituents were analyzed, which constituents were detected, and which constituents the Agency believes to be present even though they were not detected in the untreated waste.

Under the column "Believed to Be Present," constituents other than those detected in the untreated waste are marked with a Y if EPA believes they are likely to be present in the untreated waste. Those constituents

TABLE 6-1 BDAT List Metals Detected in Untreated Waste

Parameter		Untreated		Believed to be present
		Total	TCLP	
Metals (mg/l)				
154	Antimony	.022	ND	
155	Arsenic	ND	ND	
156	Barium	ND	.228	Y
157	Beryllium	ND	ND	
158	Cadmium	ND	ND	
159	Chromium	ND	ND	Y
160	Copper	ND	ND	Y
161	Lead	967	103	
162	Mercury	.00084	ND	Y
163	Nickel	ND	ND	
164	Selenium	ND	ND	
165	Silver	ND	ND	
166	Thallium	ND	ND	
167	Vanadium	ND	ND	
168	Zinc	.295	.335	

D - Detected
ND - Not detected

marked with a Y have been detected in the treated residual(s) and thus EPA believes that they are present in the untreated waste. Constituents may not have been detected in the untreated waste for one of several reasons: (1) none of the untreated waste samples were analyzed for these constituents, (2) masking or interference by other constituents prevented detection, or (3) the specific waste is defined as being generated by a process and the process can involve a number of different constituents, only some of which would be present in any given sample.

As shown in Table 6-1, four constituents have been detected and four have been identified as believed to be present. Of the detected constituents, EPA has selected only one for regulation (lead). Of the three not being regulated, none is believed to be treatable. EPA is not regulating these three constituents because they are found at concentrations far below the regulated constituent.

7. CALCULATION OF BDAT TREATMENT STANDARDS

In this section, the actual treatment standards for waste code K046 are presented. These standards were calculated based on the performance of the demonstrated treatment system that was determined by the Agency to be the best for treating both waste codes. In Section 4, BDAT for waste code K046 was determined to be stabilization using a portland cement binder. The previous section identified the constituents to be regulated for waste code K046.

As discussed in Section 1, the Agency calculated the BDAT treatment standards for waste code K046 by following a four-step procedure: (1) editing the data; (2) correcting the remaining data for analytical interference; (3) calculating adjustment factors (variability factors) to account for process variability; and (4) calculating the actual treatment standards using variability factors and average treatment values. The four steps in this procedure are discussed in detail in Sections 7.1 through 7.4

7.1 Editing the Data

Three sets of treatment data for waste code K046 were collected by the Agency at one facility that operated a treatment system consisting of stabilization using a portland cement binder. The Agency evaluated the three data sets to determine whether the treatment system was well operated at the time of the sampling visit. The operating data collected indicate that the treatment system was well operated during the collection of all data sets. For further details on the three data sets, see the Onsite Engineering Report for K046 (USEPA 1988). All of the available data sets were used to calculate treatment standards.

Toxic Characteristic Leaching Procedure (TCLP) data were used in setting treatment standards for waste code K046, since BDAT list metals were present in the untreated waste at relatively high concentrations. For a discussion on the use of TCLP data in setting treatment standards, refer to Section 1 of this background document.

In instances where a selected constituent was not detected in the treated waste, the treated value for that constituent was assumed to be the Practical Quantification Level. This was not the case for any of the regulated constituents in K046. Analytical values for the treated waste are presented in Section 4, Tables 4-1 through 4-3 of this report.

7.2 Correcting the Remaining Data

Data values for the constituents selected for regulation were taken from the three data sets. These values were corrected in order to take into account analytical interferences associated with the chemical makeup of the treated sample. This was accomplished by calculating an accuracy factor from the percent recoveries for each selected constituent. The reciprocal of the lower of the two recovery values, divided by 100, yields the accuracy factor. The corrected concentration for each constituent in each sample set is obtained by multiplying the accuracy factor by the uncorrected data value. The calculation of recovery values is described in Section 1 of this background document. The actual recovery values and accuracy factors for the selected constituents are presented in Table 5-1.

The accuracy factor calculated for lead in K046 was 1.29. The corrected concentration values for the selected constituent are shown for the three data sets for cement stabilization in Table 7-1. These corrected concentration values were obtained by multiplying the accuracy factors by the concentration values for the selected constituent in the treated waste. An arithmetic average value, representing the treated waste concentration, was calculated for the selected constituent from the three corrected values. This average is presented in Table 7-1.

7.3 Calculating the Variability Factors

It is expected that in normal operation of a well-designed and well-operated treatment system there will be some variability in performance. Based on the test data, a measure of this variability is expressed by the variability factor (see Appendix A). This factor was calculated for the selected regulated constituent. The methodology for calculating variability factors is explained in Appendix A of this report. Table 7-1 presents the results of calculations for the selected constituent. Appendix D of this report shows how the actual value in Table 7-1 was calculated.

The variability factor calculated for lead in K046 was 1.76. For comparison, a variability factor of 1.0 represents test data from a process measured without variation and analytical interferences.

TABLE 7-1 **Regulated Constituents and Calculated Treatment Standards for K046 Nonwastewaters**[1]

Constituent	Accuracy-Corrected Concentration (mg/l)			Average Treated Waste Concentration (mg/l)	Variability Factor (VF)	Treatment Standard (mg/l) (Average X VF)
	Sample Set #1	Sample Set #2	Sample Set #3			
K046						
Lead	0.093	0.129	0.079	0.100	1.76	0.18

1 - Accuracy Correction Factors and Variability Factors were determined as discussed in Appendix D.

7.4 Calculating the Treatment Standards

The treatment standard for the selected constituent was calculated by multiplying the variability factor by the average concentration value for the treated waste. The treatment standard is presented in Table 7-1.

The BDAT treatment standard for waste code K046 is as follows:

Constituent	TCLP extract (mg/l)
Lead	0.18

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APPENDIX A

STATISTICAL METHODS

A.1 F Value Determination for ANOVA Test

As noted in Section 1.2, EPA is using the statistical method known as analysis of variance (ANOVA) to determine the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets.

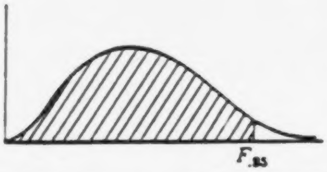
If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long-term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), the "best" technology would be the technology that achieves the best level of performance, i.e., the technology with the lowest mean value.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Table A-1

95th PERCENTILE VALUES FOR THE *F* DISTRIBUTION

n_1 = degrees of freedom for numerator
n_2 = degrees of freedom for denominator
(shaded area = .95)



n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.46	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

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Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

MSB = SSB/(k-1) and
MSW = SSW/(N-k).

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F value
Between	k-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case in which one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

	Steam stripping				Biological treatment		
Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	$[\ln(\text{effluent})]^2$
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-		12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
	1.15	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 1 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$n_1 = 10,\ n_2 = 5,\ N = 15,\ k = 2,\ T_1 = 23.18,\ T_2 = 12.46,\ T = 35.64,\ T^2 = 1270.21$

$T_1^2 = 537.31\quad T_2^2 = 155.25$

$$SSB = \left(\frac{537.31}{10} + \frac{155.25}{5}\right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left(\frac{537.31}{10} + \frac{155.25}{5}\right) = 0.77$$

$MSB = 0.10/1 = 0.10$

$MSW = 0.77/13 = 0.06$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2
Trichloroethylene

Steam stripping				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.44	19.71				
160.00	10.00	2.30	5.29				
Sum:							
	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	
Variability Factor:							
-	3.70	-	-	-	1.53	-	

ANOVA Calculations:

$$SSB \left[\sum_{i=1}^{k} \left(\frac{T_i^{\,2}}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2{}_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$MSB = SSB/(k-1)$

$MSW - SSW/(N-k)$

Example 2 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 10$, $N_2 = 7$, $N = 17$, $k = 2$, $T_1 = 26.14$, $T_2 = 16.59$, $T = 42.73$, $T^2 = 1825.85$, $T_1^2 = 683.30$,

$T_2^2 = 275.23$

$$SSB = \left(\frac{683.30}{10} + \frac{275.23}{7}\right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left(\frac{683.30}{10} + \frac{275.23}{7}\right) = 4.79$$

$MSB = 0.25/1 = 0.25$

$MSW = 4.79/15 = 0.32$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	ln[(effluent)]^2
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.20	-	-	38.90	228.34
Sample Size:							
4	4	4	-	/	/	/	-
Mean:							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation:							
1835.4	32.24	.95		16311.86	379.04	1.42	-
Variability Factor:							
-	7.00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB - \left[\sum_{i=1}^{k} \left(\frac{T_i^{\,2}}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2{}_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i{}^2}{n_i} \right)$$

$MSB = SSB/(k-1)$

$MSW = SSW/(N-k)$

$F = MSB/MSW$

Example 3 (Continued)

where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 4,\ N_2 = 7,\ N = 11,\ k = 2,\ T_1 = 14.49,\ T_2 = 38.90,\ T = 53.39,\ T^2 = 2850.49,\ T_1^2 = 209.96$

$T_2^2 = 1513.21$

$$SSB = \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) = 14.88$$

$MSB = 9.52/1 = 9.52$

$MSW = 14.88/9 = 1.65$

$F = 9.52/1.65 = 5.77$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous). Activated sludge followed by carbon adsorption is "best" in this example because the mean of the long-term performance value, i.e., the effluent concentration, is lower.

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2 Variability Factor

$$VF = \frac{C_{99}}{\text{Mean}}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data;

C_{99} = estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = \text{Exp}(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data; and

Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and, hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data show that the treatment residual concentrations are distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean), as follows:

$$VF = \frac{C_{99}}{Mean}. \qquad (1)$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally distributed concentrations can be found in most mathematical statistics texts (see, for example, Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\sigma) \qquad (2)$$

$$\text{Mean} = \text{Exp}\ (\mu + 0.5\sigma^2). \qquad (3)$$

By substituting (2) and (3) in (1), the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp}\ (2.33\ \sigma - 0.5\sigma^2). \qquad (4)$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a variability factor.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.

- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).

- Assumption 3: The standard deviation (σ) of the normal distribution is approximated by:

$$\begin{aligned}\sigma &= [\ln(UL) - \ln(LL)] / [(2)(2.33)] \\ &= [\ln(UL/LL)] / 4.66. \qquad (5)\end{aligned}$$

(Note that when LL = (0.1)(UL) as in Assumption 1, then $\sigma = (\ln 10) / 4.66 = 0.494$.)

Substitution of the σ value from equation (5) into equation (4) yields the variability factor, VF, as shown:

$$VF = 2.8. \qquad (6)$$

APPENDIX B - ANALYTICAL QA/QC

The analytical methods used for analysis of the regulated constituents identified in Section 5 are listed in Table B-1. SW-846 methods (EPA's Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846, Third Edition, November 1986) are used in most cases for determining total waste concentrations.

SW-846 allows for the use of alternative or equivalent procedures or equipment; these are described in Table B-2. These alternatives or equivalents included use of alternative sample preparation methods and/or use of different extraction techniques to reduce sample matrix interferences.

The accuracy factor determination for a constituent is based on the matrix spike recovery values. Table B-3 presents the matrix spike recovery values for TCLP extract concentrations of BDAT list metals and non-BDAT list metals for K046.

The accuracy-correction factors were determined in accordance with the general methodology presented in the Introduction. For example, for lead, actual spike recovery data were obtained for analysis of liquid matrices, and the lowest percent recovery value was used to calculate the accuracy-correction factor. An example of the calculation of the corrected concentration value for lead in K046 (using a cement binder) is shown below. The analytical value is the uncorrected concentration from Table 4-1 (or Table B-3). The percent recovery value is taken from Table B-3.

TABLE B-1 Analytical Methods

Analytial Method	Method No.	Reference
Inductively Coupled Plasma Atomic Emission Spectroscopy (aluminum/antimony/barium/beryllium/cadmium/calcium/chromium/cobalt/copper/iron/magnesium/manganese/nickel/silver/sodium/tin/vanadium/zinc/lead)	6010	1
Arsenic (Atomic Absorption, Furnace Technique)	7060	1
Selenium (Atomic Adsorption, Furnace Technique)	7740	1
Mercury in Liquid Waste (Manual Cold-Vapor Technique)	7470	1
Lead (Atomic Adsorption, Furnace Technique)	7421	1
Thallium (Atomic Adsorption, Furnace Technique)	7841	1
Hexavalent Chromium	7196	1
TCLP	51 FR 40643	2
TOC	9060	1
Chloride	9252	1
Sulfate	9038	1
Oil and Grease	9071	1
Particle Size Distribution	D 422	3

References:

1. U.S. Environmental Protection Agency. 1986. Test Methodology for Evaluating Solid Waste. Third Edition, U.S. E.P.A. Office of Solid Waste and Emergency Response, November 1986.

2. Federal Register, 1986. Hazardous Waste Management Systems; Land Disposal Restrictions; Final Rule; Appendix I to Part 268 - Toxicity Leaching Procedure (TCLP). Vol. 51, No. 216. November 7, 1986. pp. 40643-40654.

3. American Society for Testing and Materials. 1986. Annual Book of ASTM Standards. Philadelphia, PA. 1986.

TABLE B-2 Specific Procedures or Equipment Used in Preparation and Analysis of Metals When Alternative or Equivalents Allowed in the SW-846 Methods

Analysis	SW-846 Method	Equipment	Alternative or Equivalent Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Inductively coupled plasma atomic emission spectroscopy	6010	Perkin Elmer Plasma II Emission Spectrophotometers	• Operate equipment following instructions provided by instrument's manufacturer.	• Equipment operated using procedures specified in the Perkin Elmer Plasma II Emission Spectrophotometer Operator's Manual.
			• For operation with organic solvents, auxiliary argon gas inlet is recommended.	• Auxiliary argon gas was not required for sample matrix.
Metals by Furnace AA Thallium Selenium Lead Arsenic	 7841 7740 7421 7060	(1) Perkin Elmer 560 (2) Perkin Elmer HGA 2200 Graphite Furnaces	• Operate equipment following instructions provided by instrument's manufacturer.	• Equipment operated using procedures specified in Perkin Elmer instruction manuals.
			• For background correction use either continuous correction or alternatives, e.g., Zeeman correction.	• Background detection was used.
			• If samples contain a large amount of organic material, they should be oxidized by conventional acid digestion before being analyzed.	• Sample preparation using a hydrochloric acid digestion was not used.
Mercury	7471	Perkin Elmer 560	• Operate equipment following instructions by instrument's manufacturer.	• Equipment operated using procedures specified in Perkin Elmer 560 Instruction Manual.
			• Cold vapor apparatus is described in SW-846 or an equivalent apparatus may be used.	• Mercury was analyzed by cold vapor method using the apparatus as specified in SW-846.
			• Sample may be prepared using the water bath method or the autoclave method described in SW-846.	• Samples were prepared using the water bath method.

TABLE B-3 Matrix Spike for Metals for the TCLP Extract for the Cement Binder K046

Spike Constituent	Original Amount Found (mg/l)	Amount Spiked (mg/l)	Matrix Spike Amount Found (mg/l)	Matrix Spike Percent Recovery*	Matrix Spike Duplicate Amount Found (mg/l)	Matrix Spike Duplicate Percent Recovery*	Relative Percent Recovery**
BDAT Metals							
Antimony	<0.017	1	0.96	96	0.95	95	1
Arsenic	<0.003	0.1	0.118	118	0.113	113	4
Barium	1.8	1	2.84	104	2.90	110	6
Beryllium	<0.002	1	0.89	89	0.96	96	8
Cadmium	<0.005	1	0.96	96	0.99	99	3
Chromium-total	<0.03	1	0.98	95	0.98	95	0
Chromium-hexavalent	<0.06	1	0.38	94	NA	NA	NC
Copper	<0.019	1	0.86	84	0.82	81	4
Lead	<0.061	1	0.82	77	0.82	77	0
Mercury	<0.0003	0.05	0.0471	94	0.0505	101	7
Nickel	<0.03	1	0.88	88	0.98	98	11
Selenium	<0.002	0.05	0.054	108	0.043	87	22
Silver	<0.006	1	0.25	25	0.42	42	51
Thallium	<0.001	1	0.2	20	0.15	15	29
Vanadium	<0.008	1	0.91	91	0.95	95	4
Zinc	<0.02	1	1.07	96	1.09	98	2
Non-BDAT Metals							
Aluminum	0.311	1	1.20	89	1.19	88	1
Calcium	2140	1	NC	NC	NC	NC	NC
Cobalt	<0.04	1	0.93	93	0.90	90	3
Iron	<0.112	1	0.93	82	0.98	86	5
Magnesium	0.025	1	0.92	90	0.99	96	6
Manganese	<0.002	1	0.93	93	0.96	96	3
Sodium	331	1	NC	NC	NC	NC	NC
Tin	<0.983	1	0.60	60	0.76	76	24

NA - Not Analyzed

NC - Not Calculatable

* Percent Recovery = 100(C_i - C_o)/C_t, where C_o is the initial concentration, C_i is the concentration of the spiked aliquot, and C_t is the concentration of the spike added.

** Relative Percent Difference - 100 (D_1 - D_2/(D_1 + D_2)/2), where D_1, is the larger of the two observed values for Percent Recovery

continued

TABLE B-4 Matrix Spike for Metals for the TCLP Extract for the Kiln Dust K046

	Original		Matrix Spike		Matrix Spike Duplicate		
Spike Constituent	Amount Found (mg/l)	Amount Spiked (mg/l)	Amount Found (mg/l)	Percent Recovery*	Amount Found (mg/l)	Percent Recovery*	Relative Percent Recovery**
BDAT Metals							
Antimony	<0.017	1	0.85	85	0.92	92	1
Arsenic	<0.003	0.1	0.115	115	0.122	107	4
Barium	0.3	1	1.38	108	1.36	106	6
Beryllium	<0.002	1	0.70	70	0.72	72	8
Cadmium	<0.005	1	0.77	77	0.73	73	3
Chromium-total	0.06	1	0.85	79	0.87	81	0
Chromium-hexavalent	0.06	1	1.29	123	1.23	117	-
Copper	<0.006	1	0.83	83	0.83	83	4
Lead	0.68	1	1.52	91	1.59	95	4
Mercury	<0.0003	0.05	0.0540	108	0.0575	115	7
Nickel	<0.03	1	0.74	74	0.73	73	11
Selenium	0.012	0.05	0.058	91	0.067	110	22
Silver	<0.006	1	0.13	13	0.32	32	84
Thallium	0.007	1	0.55	55	0.51	51	8
Vanadium	<0.008	1	0.86	86	0.88	88	4
Zinc	<0.002	1	0.69	69	0.72	72	2
Non-BDAT Metals							
Aluminum	<0.016	1	0.89	89	0.87	87	1
Calcium	2134	1	NC	NC	NC	NC	NC
Cobalt	<0.04	1	0.77	77	0.81	81	3
Iron	<0.02	1	0.71	71	0.76	76	5
Magnesium	0.02	1	0.76	74	0.78	76	6
Manganese	<0.002	1	0.89	89	0.76	76	3
Sodium	201	1	NC	NC	NC	NC	NC
Tin	<0.983	1	0.67	67	0.70	71	24

NA - Not Analyzed
NC - Not Calculatable

* Percent Recovery = 100(C_i - C_o)/C_t, where C_o is the initial concentration, C_i is the concentration of the spiked aliquot, and C_t is the concentration of the spike added.

** Relative Percent Difference - 100 (D_1 - D_2/(D_1 + D_2)/2), where D_1, is the larger of the two observed values for Percent Recovery

continued

TABLE B-5 Matrix Spike for Metals for the TCLP Extract for the Fly Ash Binder

K046

			Matrix Spike		Matrix Spike Duplicate		
Spike Constituent	Original Amount Found (mg/l)	Amount Spiked (mg/l)	Amount Found (mg/l)	Percent Recovery*	Amount Found (mg/l)	Percent Recovery*	Relative Percent Recovery**
BDAT Metals							
Antimony	<0.017	1	0.74	74	0.77	77	4
Arsenic	<0.003	0.1	0.122	122	0.124	124	2
Barium	3.5	1	4.49	99	4.34	84	16
Beryllium	<0.002	1	0.66	66	0.72	72	9
Cadmium	<0.005	1	0.69	69	0.69	69	0
Chromium-total	<0.02	1	0.75	75	0.82	82	9
Chromium-hexavalent	<0.064	1	0.94	94	NA	NA	NC
Copper	0.01	1	0.84	83	0.83	82	1
Lead	0.56	1	1.08	70	1.20	77	10
Mercury	<0.0003	0.05	0.0489	98	0.0458	92	6
Nickel	<0.03	1	0.67	67	0.74	75	11
Selenium	<0.002	0.05	0.37	75	0.037	74	1
Silver	<0.006	1	0.22	22	0.39	39	56
Thallium	0.002	1	0.68	67	0.71	71	6
Vanadium	<0.008	1	0.87	87	0.86	86	1
Zinc	<0.02	1	0.67	67	0.74	74	9
Non-BDAT Metals							
Aluminum	0.2	1	1.16	96	1.12	92	4
Calcium	2366	1	NC	NC	NC	NC	NC
Cobalt	<0.04	1	0.77	77	0.79	79	3
Iron	<0.02	1	0.76	76	0.75	75	1
Magnesium	0.003	1	0.79	79	0.77	77	3
Manganese	<0.002	1	0.78	78	0.77	77	1
Sodium	280	1	NC	NC	NC	NC	NC
Tin	<0.983	1	0.77	77	0.70	70	10

NA - Not Analyzed

NC - Not Calculatable

* Percent Recovery = 100(C_i - C_o)/C_t, where C_o is the initial concentration, C_i is the concentration of the spiked aliquot, and C_t is the concentration of the spike added.

** Relative Percent Difference - 100 (D_1 - D_2/(D_1 + D_2)/2), where D_1, is the larger of the two observed values for Percent Recovery

continued

Analytical value	% Recovery	Correction factor	Corrected value
0.061 mg/l	77	$\frac{100}{77} = 1.30$	1.30 x 0.061 = 0.079 mg/l

APPENDIX C

DETECTION LIMITS FOR UNTREATED AND TREATED K046 WASTE

Table C-1 shows detection limits for the metal constituents in untreated K046 waste. Table C-2 shows detection limits for three types of stabilized K046 waste.

TABLE C-1 DETECTION LIMITS FOR UNTREATED K046

BDAT CONSTITUENTS	DETECTION LIMIT (mg/l) UNTREATED K046
Metals	
154 Antimony	0.02
155 Arsenic	0.01
156 Barium	0.2
157 Beryllium	0.005
158 Cadmium	0.01
159 Chromium	0.02
160 Copper	0.025
161 Lead	0.01
162 Mercury	0.0003
163 Nickel	0.04
164 Selenium	0.005
165 Silver	0.05
166 Thallium	0.01
167 Vanadium	0.05
168 Zinc	0.05

TABLE C-2 DETECTION LIMITS FOR TREATED K046

BDAT CONSTITUENTS	DETECTION LIMIT (mg/l) CEMENT	KILN DUST	LIME/FLYASH
Metals			
154 Antimony	0.17	0.17	0.17
155 Arsenic	0.003	0.003	0.003
156 Barium	0.002	0.002	0.002
157 Beryllium	0.002	0.002	0.002
158 Cadmium	0.005	0.005	0.005
159 Chromium	0.02	0.02	0.02
160 Copper	0.006	0.006	0.006
161 Lead	0.002	0.002	0.002
162 Mercury	0.0003	0.0003	0.0003
163 Nickel	0.03	0.03	0.03
164 Selenium	0.002	0.002	0.002
165 Silver	0.006	0.006	0.006
166 Thallium	0.0007	0.0007	0.0007
167 Vanadium	0.008	0.008	0.008
168 Zinc	0.02	0.02	0.02

APPENDIX D

CALCULATION OF TREATMENT STANDARDS

This appendix shows (1) the calculation of the K046 lead treatment standard in K046 nonwastewater and (2) the ANOVA which stabilization binder provided the best treatment.

APPENDIX D   CALCULATION OF TREATMENT STANDARDS

Constituent: Lead

Sample Set	1 Treated (TCLP) Concentration (mg/l)	2 Percent Recovery	3 Accuracy Correction Factor	4 Corrected Concentration (mg/l)	5 Log Transform
1	0.072	77.4	1.29	0.093	-2.375
2	0.100	77.4	1.29	0.129	-2.048
3	0.061	77.4	1.29	0.079	-2.538
			x =	0.100	y = -2.320
					s = 0.250

1 - Obtained from the Onsite Engineering Report for K046 (Waterways Experiment Station).
2 - Obtained from the Onsite Engineering Report for K046 (Waterways Experiment Station).
3 - Accuracy Correction Factor = 100 / Percent Recovery.
4 - Corrected Concentration = Effluent Concentration X Accuracy Correction Factor.
5 - Log Transform using the natural logarithm, ln, of the Corrected Concentration.

Treatment Standard = Corrected Effluent Mean X VF

Calculation of Variability Factor (VF):

C99 = exp (y + 2.33s)
where
y = the mean of the log transforms
s = the standard deviation of the log transforms.

Therefore, C99 = exp (-2.320 + 0.583)
= exp (-1.737)
= 0.176

and VF = C99 / x
where
x = the mean of the corrected effluent concentrations.

Therefore, VF = C99 / x
= 0.176 / 0.100
= 1.76

Treatment Standard = Corrected Effluent Mean X VF
= 0.100 X 1.76
= 0.176 mg/l

ANOVA FOR K046

I. DETERMINE ACCURACY FACTORS

	CEMENT			KILN DUST			LIME/FLYASH		
Component	MS	MSD	AF	MS	MSD	AF	MS	MSD	AF
Lead	77.4	77.4	1.29	90.5	94.5	1.10	69.5	77.2	1.44
Zinc	96	98	1.04	69	72	1.45	67	74	1.49

II. CORRECT AND LOG-TRANSFORM ALL DATA
(all results are in mg/L)

	CEMENT			KILN DUST			LIME/FLYASH		
Component	A	B	C	A	B	C	A	B	C
Lead									
Raw	0.072	0.100	0.062	0.900	1.100	1.000	0.400	0.400	0.400
Correct	0.093	0.129	0.080	0.994	1.215	1.105	0.576	0.576	0.576
Log	-2.375	-2.046	-2.524	-0.006	0.195	0.100	-0.552	-0.552	-0.552
Log2	5.640	4.188	6.373	0.000	0.038	0.010	0.305	0.305	0.305
Zinc									
Raw	0.036	0.027	0.112	0.020	0.020	0.020	0.040	0.020	0.020
Correct	0.038	0.028	0.117	0.029	0.029	0.029	0.060	0.030	0.030
Log	-3.283	-3.571	-2.148	-3.541	-3.541	-3.541	-2.818	-3.512	-3.512
Log2	10.781	12.753	4.616	12.538	12.538	12.538	7.943	12.331	12.331

III. USE F-TEST TO COMPARE ALL TREATMENTS

1) Lead

Units = mg/l

	CEMENT				KILN DUST				LIME/FLYASH			
Component	A	B	C	SUM	A	B	C	SUM	A	B	C	SUM
Lead												
Raw	0.072	0.100	0.062		0.900	1.100	1.000		0.400	0.400	0.400	
Correct	0.093	0.129	0.080		0.994	1.215	1.105		0.576	0.576	0.576	
Log	-2.375	-2.046	-2.524	-6.946	-0.006	0.195	0.100	0.289	-0.552	-0.552	-0.552	-1.657
Log2	5.640	4.188	6.373	16.201	0.000	0.038	0.010	0.048	0.305	0.305	0.305	0.916

k = 3 number of treatments
n1 = 3 number of data points for technology 1 (cement)
n2 = 3 number of data points for technology 2 (kiln dust)
n3 = 3 number of data points for technology 3 (lime/flyash)
N = 9 number of data points for all technologies

SSB = 9.34
MSB = 4.67

SSW = 0.14
MSW = 0.02

F = 200.61

F(k-1,N-k,0.05) = F(2,6,0.05) = 5.14

2) Zinc

Units = mg/l

	CEMENT				KILN DUST				LIME/FLYASH			
Component	A	B	C	SUM	A	B	C	SUM	A	B	C	SUM
Zinc												
Raw	0.036	0.027	0.112		0.020	0.020	0.020		0.040	0.020	0.020	
Correct	0.038	0.028	0.117		0.029	0.029	0.029		0.060	0.030	0.030	
Log	-3.283	-3.571	-2.148	-9.003	-3.541	-3.541	-3.541	-10.623	-2.818	-3.512	-3.512	-9.841
Log2	10.781	12.753	4.616	28.149	12.538	12.538	12.538	37.615	7.943	12.331	12.331	32.605

k = 3 number of treatments
n1 = 3 number of data points for technology 1 (cement)
n2 = 3 number of data points for technology 2 (kiln dust)
n3 = 3 number of data points for technology 3 (lime/flyash)
N = 9 number of data points for all technologies

SSB = 0.44
MSB = 0.22

SSW = 1.45
MSW = 0.24

F = 0.90

F(k-1,N-k,0.05) = F(2,6,0.05) = 5.14

ANOVA FOR K046 (CEMENT/KILN DUST)

I. DETERMINE ACCURACY FACTORS

	CEMENT			KILN DUST			LIME/FLYASH		
Component	MS	MSD	AF	MS	MSD	AF	MS	MSD	AF
Lead	77.4	77.4	1.29	90.5	94.5	1.10	69.5	77.2	1.44
Zinc	96	98	1.04	69	72	1.45	67	74	1.49

II. CORRECT AND LOG-TRANSFORM ALL DATA
(all results are in mg/L)

	CEMENT			KILN DUST			LIME/FLYASH		
Component	A	B	C	A	B	C	A	B	C
Lead									
Raw	0.072	0.100	0.062	0.900	1.100	1.000	0.400	0.400	0.400
Correct	0.093	0.129	0.080	0.994	1.215	1.105	0.576	0.576	0.576
Log	-2.375	-2.046	-2.524	-0.006	0.195	0.100	-0.552	-0.552	-0.552
Log2	5.640	4.188	6.373	0.000	0.038	0.010	0.305	0.305	0.305
Zinc									
Raw	0.036	0.027	0.112	0.020	0.020	0.020	0.040	0.020	0.020
Correct	0.038	0.028	0.117	0.029	0.029	0.029	0,060	0.030	0.030
Log	-3.283	-3.571	-2.148	-3.541	-3.541	-3.541	-2.818	-3.512	-3.512
Log2	10.781	12.753	4.616	12.538	12.538	12.538	7.943	12.331	12.331

III. USE F-TEST TO COMPARE TWO TREATMENTS

1) Lead

Units = mg/l

	CEMENT				KILN DUST			
Component	A	B	C	SUM	A	B	C	SUM
Lead								
Raw	0.072	0.100	0.062		0.900	1.100	1.000	
Correct	0.093	0.129	0.080		0.994	1.215	1.105	
Log	-2.375	-2.046	-2.524	-6.946	-0.006	0.195	0.100	0.289
Log2	5.640	4.188	6.373	16.201	0.000	0.038	0.010	0.048

k = 2 number of treatments
n1 = 3 number of data points for technology 1 (cement)
n2 = 3 number of data points for technology 2 (kiln dust)
n3 = 0 number of data points for technology 3 (lime/flyash)
N = 6 number of data points for all technologies

SSB = 8.72
MSB = 8.72

SSW = 0.14
MSW = 0.03

F = 249.72

F(k-1,N-k,0.05) = F(1,4,0.05) = 7.71

2) Zinc

Units = mg/l

Component	CEMENT				KILN DUST			
	A	B	C	SUM	A	B	C	SUM
Zinc								
Raw	0.036	0.027	0.112		0.020	0.020	0.020	
Correct	0.038	0.028	0.117		0.029	0.029	0.029	
Log	-3.283	-3.571	-2.148	-9.003	-3.541	-3.541	-3.541	-10.623
Log2	10.781	12.753	4.616	28.149	12.538	12.538	12.538	37.615

k = 2 number of treatments
n1 = 3 number of data points for technology 1 (cement)
n2 = 3 number of data points for technology 2 (kiln dust)
n3 = 0 number of data points for technology 3 (lime/flyash)
N = 6 number of data points for all technologies

SSB = 0.44
MSB = 0.44

SSW = 1.13
MSW = 0.28

F = 1.55

F(k-1,N-k,0.05) = F(1,4,0.05) = 7.71

ANOVA FOR K046 (CEMENT/LIME)

I. DETERMINE ACCURACY FACTORS

	CEMENT			KILN DUST			LIME/FLYASH		
Component	MS	MSD	AF	MS	MSD	AF	MS	MSD	AF
Lead	77.4	77.4	1.29	90.5	94.5	1.10	69.5	77.2	1.44
Zinc	96	98	1.04	69	72	1.45	67	74	1.49

II. CORRECT AND LOG-TRANSFORM ALL DATA

(all results are in mg/L)

	CEMENT			KILN DUST			LIME/FLYASH		
Component	A	B	C	A	B	C	A	B	C
Lead									
Raw	0.072	0.100	0.062	0.900	1.100	1.000	0.400	0.400	0.400
Correct	0.093	0.129	0.080	0.994	1.215	1.105	0.576	0.576	0.576
Log	-2.375	-2.046	-2.524	-0.006	0.195	0.100	-0.552	-0.552	-0.552
Log2	5.640	4.188	6.373	0.000	0.038	0.010	0.305	0.305	0.305
Zinc									
Raw	0.036	0.027	0.112	0.020	0.020	0.020	0.040	0.020	0.020
Correct	0.038	0.028	0.117	0.029	0.029	0.029	0.060	0.030	0.030
Log	-3.283	-3.571	-2.148	-3.541	-3.541	-3.541	-2.818	-3.512	-3.512
Log2	10.781	12.753	4.616	12.538	12.538	12.538	7.943	12.331	12.331

III. USE F-TEST TO COMPARE TWO TREATMENTS (CEMENT AND LIME/FLYASH)

1) Lead

Units = mg/l

	CEMENT				LIME/FLYASH			
Component	A	B	C	SUM	A	B	C	SUM
Lead								
Raw	0.072	0.100	0.062		0.400	0.400	0.400	
Correct	0.093	0.129	0.080		0.576	0.576	0.576	
Log	-2.375	-2.046	-2.524	-6.946	-0.552	-0.552	-0.552	-1.657
Log2	5.640	4.188	6.373	16.201	0.305	0.305	0.305	0.916

k = 2 number of treatments
n1 = 3 number of data points for technology 1 (cement)
n2 = 0 number of data points for technology 2 (kiln dust)
n3 = 3 number of data points for technology 3 (lime/flyash)
N = 6 number of data points for all technologies

SSB = 4.66
MSB = 4.66

SSW = 0.12
MSW = 0.03

F = 155.90

F(k-1,N-k,0.05) = F(1,4,0.05) = 7.71

2) Zinc

Units = mg/l

	CEMENT				LIME/FLYASH			
Component	A	B	C	SUM	A	B	C	SUM
Zinc								
Raw	0.036	0.027	0.112		0.040	0.020	0.020	
Correct	0.038	0.028	0.117		0.060	0.030	0.030	
Log	-3.283	-3.571	-2.148	-9.003	-2.818	-3.512	-3.512	-9.841
Log2	10.781	12.753	4.616	28.149	7.943	12.331	12.331	32.605

k = 2 number of treatments
n1 = 3 number of data points for technology 1 (cement)
n2 = 0 number of data points for technology 2 (kiln dust)
n3 = 3 number of data points for technology 3 (lime/flyash)
N = 6 number of data points for all technologies

SSB = 0.12
MSB = 0.12

SSW = 1.45
MSW = 0.36

F = 0.32

F(k-1,N-k,0.05) = F(1,4,0.05) = 7.71

ANOVA FOR K046 (KILN DUST/LIME)

I. DETERMINE ACCURACY FACTORS

	CEMENT			KILN DUST			LIME/FLYASH		
Component	MS	MSD	AF	MS	MSD	AF	MS	MSD	AF
Lead	77.4	77.4	1.29	90.5	94.5	1.10	69.5	77.2	1.44
Zinc	96	98	1.04	69	72	1.45	67	74	1.49

II. CORRECT AND LOG-TRANSFORM ALL DATA

(all results are in mg/L)

	CEMENT			KILN DUST			LIME/FLYASH		
Component	A	B	C	A	B	C	A	B	C
Lead									
Raw	0.072	0.100	0.062	0.900	1.100	1.000	0.400	0.400	0.400
Correct	0.093	0.129	0.080	0.994	1.215	1.105	0.576	0.576	0.576
Log	-2.375	-2.046	-2.524	-0.006	0.195	0.100	-0.552	-0.552	-0.552
Log2	5.640	4.188	6.373	0.000	0.038	0.010	0.305	0.305	0.305
Zinc									
Raw	0.036	0.027	0.112	0.020	0.020	0.020	0.040	0.020	0.020
Correct	0.038	0.028	0.117	0.029	0.029	0.029	0.060	0.030	0.030
Log	-3.283	-3.571	-2.148	-3.541	-3.541	-3.541	-2.818	-3.512	-3.512
Log2	10.781	12.753	4.616	12.538	12.538	12.538	7.943	12.331	12.331

III. USE F-TEST TO COMPARE TWO TREATMENTS (KILN DUST AND LIME/FLYASH)

1) Lead

Units = mg/l

	KILN DUST				LIME/FLYASH			
Component	A	B	C	SUM	A	B	C	SUM
Lead								
Raw	0.900	1.100	1.000		0.400	0.400	0.400	
Correct	0.994	1.215	1.105		0.576	0.576	0.576	
Log	-0.006	0.195	0.100	0.289	-0.552	-0.552	-0.552	-1.657
Log2	0.000	0.038	0.010	0.048	0.305	0.305	0.305	0.916

k = 2 number of treatments
n1 = 0 number of data points for technology 1 (cement)
n2 = 3 number of data points for technology 2 (kiln dust)
n3 = 3 number of data points for technology 3 (lime/flyash)
N = 6 number of data points for all technologies

SSB = 0.63
MSB = 0.63

SSW = 0.02
MSW = 0.01

F = 125.38

F(k-1,N-k,0.05) = F(1,4,0.05) = 7.71

2) Zinc

Units = mg/l

	KILN DUST				LIME/FLYASH			
Component	A	B	C	SUM	A	B	C	SUM
Zinc								
Raw	0.020	0.020	0.020		0.040	0.020	0.020	
Correct	0.029	0.029	0.029		0.060	0.030	0.030	
Log	-3.541	-3.541	-3.541	-10.623	-2.818	-3.512	-3.512	-9.841
Log2	12.538	12.538	12.538	37.615	7.943	12.331	12.331	32.605

k = 2 number of treatments
n1 = 0 number of data points for technology 1 (cement)
n2 = 3 number of data points for technology 2 (kiln dust)
n3 = 3 number of data points for technology 3 (lime/flyash)
N = 6 number of data points for all technologies

SSB = 0.10
MSB = 0.10

SSW = 0.32
MSW = 0.08

F = 1.27

F(k-1,N-k,0.05) = F(1,4,0.05) = 7.71

DETERMINATION OF SIGNIFICANT TREATMENT

I. DETERMINE ACCURACY FACTORS

		CEMENT	
Component	MS	MSD	AF
Lead	77.4	77.4	1.29
Zinc	96	98	1.04

II. CORRECT AND LOG-TRANSFORM ALL DATA

(all results are in mg/l)

	UNTREATED		CEMENT	
Component	TCLP	A	B	C
Lead				
Raw	103	0.072	0.100	0.061
Correct	133.075	0.093	0.129	0.079
Log	4.891	-2.375	-2.046	-2.541
Log2	23.921	5.640	4.188	6.455
Zinc				
Raw	0.335	0.036	0.027	0.112
Correct	0.349	0.038	0.028	0.117
Log	-1.053	-3.283	-3.571	-2.148
Log2	1.108	10.781	12.753	4.616

III. USE F-TEST TO COMPARE UNTREATED AND TREATED WASTE (FOR CEMENT BINDER)

1) Lead

Units = mg/l

Component			CEMENT		
		A	B	C	SUM
Lead					
Raw	103.000	0.072	0.100	0.061	
Correct	133.075	0.093	0.129	0.079	
Log	4.891	-2.375	-2.046	-2.541	-6.962
Log2	23.921	5.640	4.188	6.455	16.283

k = 2 number of treatments
n1 = 1 number of data points for technology 1 (untreated)
n2 = 3 number of data points for technology 2 (treated)
n3 = 0 number of data points for technology 3
N = 4 number of data points for all technologies

SSB = 39.01
MSB = 39.01

SSW = 0.13
MSW = 0.06

F = 616.31

F(k-1,N-k,0.05) = F(1,2,0.05) = 18.5

2) Zinc

Units = mg/l

			CEMENT		
Component		A	B	C	SUM
Zinc					
Raw	0.335	0.036	0.027	0.112	
Correct	0.349	0.038	0.028	0.117	
Log	-1.053	-3.283	-3.571	-2.148	-9.003
Log2	1.108	10.781	12.753	4.616	28.149

k = 2 number of treatments
n1 = 1 number of data points for technology 1 (untreated)
n2 = 3 number of data points for technology 2 (treated)
n3 = 0 number of data points for technology 3
N = 4 number of data points for all technologies

SSB = 2.85
MSB = 2.85

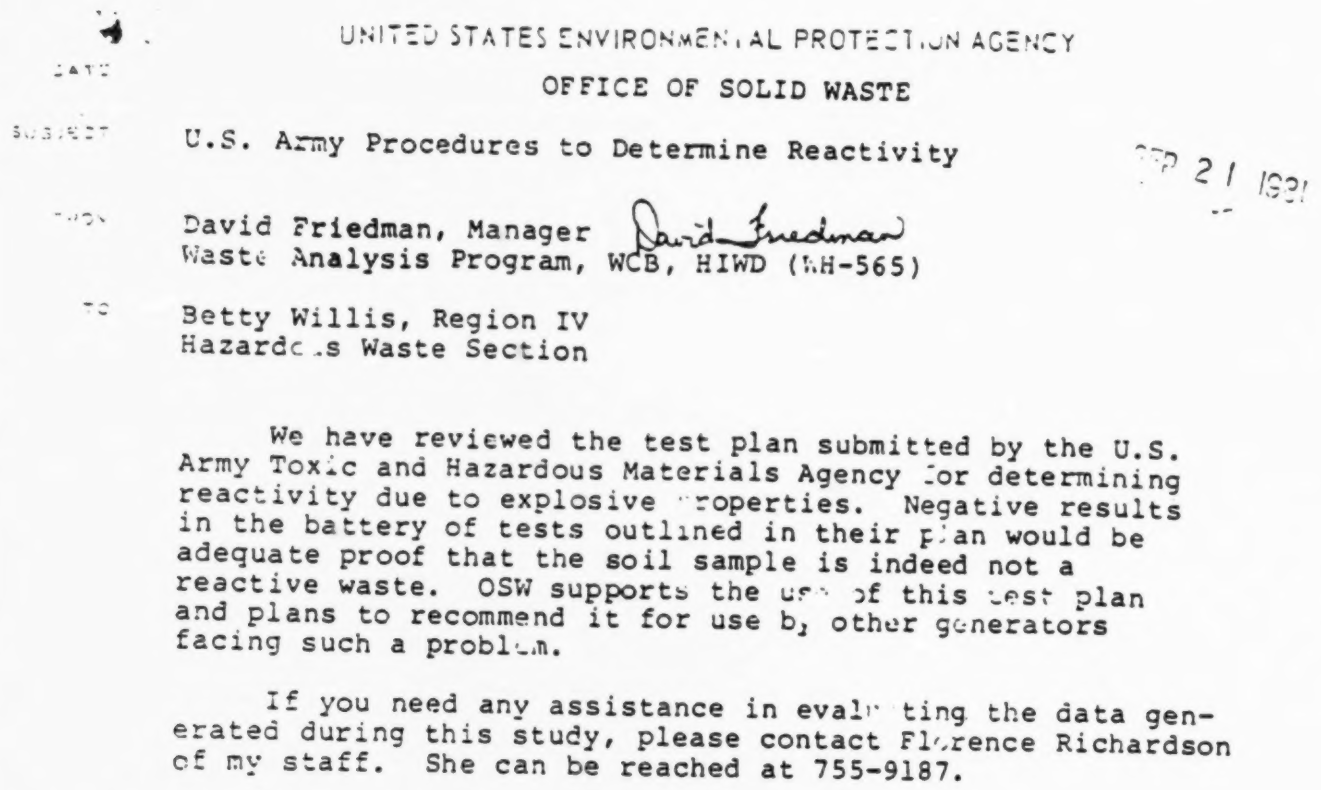
SSW = 1.13
MSW = 0.57

F = 5.03

F(k-1,N-k,0.05) = F(1,2,0.05) = 18.5

APPENDIX E

DETERMINATION OF NONREACTIVE AND REACTIVE FORMS OF K046



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF SOLID WASTE

DATE SEP 21 1981

SUBJECT U.S. Army Procedures to Determine Reactivity

FROM David Friedman, Manager David Friedman
Waste Analysis Program, WCB, HIWD (WH-565)

TO Betty Willis, Region IV
Hazardous Waste Section

We have reviewed the test plan submitted by the U.S. Army Toxic and Hazardous Materials Agency for determining reactivity due to explosive properties. Negative results in the battery of tests outlined in their plan would be adequate proof that the soil sample is indeed not a reactive waste. OSW supports the use of this test plan and plans to recommend it for use by other generators facing such a problem.

If you need any assistance in evaluating the data generated during this study, please contact Florence Richardson of my staff. She can be reached at 755-9187.

ENVIRONMENTAL PROTECTION AGENCY

REGION IV

A&HMD — Informal Memo

DATE: September 15, 1981

TO: David Friedman, (WH-565)

SUBJECT: U.S. Army Procedures to Determine Reactivity

Please review this and give me a call at FTS 257-3433 concerning how to handle this request.

FROM: Betty C. Willis

EPA, Region IV

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region IV - Atlanta, GA

DATE: SEP 0 1 1981

SUBJECT: U. S. Army Toxic & Hazardous Materials Agency
Draft Procedures to Determine Reactivity

David Friedman

FROM: Arthur G. Linton
Federal Activities Coordinator

TO: James H. Finger, Director
Surveillance & Analysis Division

✓ James H. Scarbrough, Chief
Residuals Management Branch

The U. S. Army Toxic and Hazardous Materials Agency has requested that we review the three enclosures. The purpose of this procedure is to delineate the necessary tests, associated methods, and interpretation of results to determine whether contaminated soil and sediments are classified as reactive, due to their explosive properties. This information is necessary to determine what, if any, processing is required for final disposal of such soil or sediments.

The facility this procedure has been developed for is Milan Army Ammunition Plant, Milan, Tennessee. There are eleven lagoons located at this facility that have been used to process waters containing nitrobodies; specifically, what is classified as pink water. The closing out of these lagoons has a high priority within the Army and EPA because groundwater has been contaminated within the arsenal boundaries. There is an immediate need to develop a strategy to close out these lagoons, either by filling or treating the sediments.

Feel free to contact Mr. Robert A. Breschi, who is referred to in the enclosed documents. Once your review has been completed, we need to develop a mutual time during which we can discuss this procedure with Mr. Breschi and other representatives of the U. S. Army Toxic and Hazardous Materials Agency.

I am requesting that you respond to my request by September 11, 1981. I am targeting a meeting with the U. S. Army Toxic and Hazardous Materials Agency during the week of September 21.

Arthur G. Linton
Arthur G. Linton

Enclosures

EPA Form 1320-6 (Rev. 3-76)

DEPARTMENT OF THE ARMY
US ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010

REPLY TO
ATTENTION OF
DRXTH-ES

2 5 AUG 1981

Mr. Art Linton
Federal Activities Coordinator (Rm 203)
Environmental Protection Agency
345 Courtland Street
Atlanta, Georgia 30365

Dear Mr. Linton:

In reference to our FONECON of 24 August 1981, inclosed are the draft procedures developed by US Army Toxic and Hazardous Materials Agency (USATHAMA) to determine the reactivity of the soils and sediment within the 11 lagoons situated at Milan AAP.

Inclosures 1 and 2 are copies of the procedures to determine concentrations of explosives within soil and sediment. Inclosure 3 is a copy of the reactivity procedures to determine whether soil and sediment are in fact reactive.

not enclosed to the

If there are questions call me at (301) 671-2270. Also notify me when the EPA review process is complete so a meeting can be set to discuss the procedures.

I appreciate your attention to this matter.

Sincerely,

Robert A. Breschi

3 Incl
As stated

ROBERT A. BRESCHI
Environmental Engineer
US Army Toxic and Hazardous
Materials Agency

TEST PLAN TO DETERMINE REACTIVITY OF EXPLOSIVELY CONTAMINATED SOIL AND SEDIMENT*

I. PURPOSE

The purpose of this plan is to delineate the necessary tests, associated methods, and interpretation of results to determine whether a contaminated soil of sediment is classified as reactive due to its explosive properties. Such information is necessary to determine what (if any) processing is required prior to final disposal of such soil or sediment.

II. REFERENCE

a. Title 40 Code of Federal Regulations, Part 261, Para 261.23, Characteristic of Reactivity.

b. EPA Publication SW 846, Test Method for Evaluating Solid Waste, Subsection) 6-2; Definition of Explosive Materials (attached as Incl. 1).

c. Army Technical Bulletin 700-2, Chapter 3: Minimum Test Criteria for Bulk Explosive Compositions and Solid Propellant Compositions.

d. FONECONS with Dr. H. Matsuguma, Chief, Chemistry Branch, Energetic Materials Division, Large Caliber Weapons System Laboratory, U.S. Army Armament Research and Development Command, SAB.

III. BACKGROUND

Due to explosives production, employment, and disposal operations performed through the years at various military installations across the country, the Army owns property which contains potentially explosively contaminated soils and sediments. Efforts are underway to begin decontamination and close-out of such sites in compliance with Federal Environmental Regulations. Explosives, however, are governed by Ref. 2a, which restricts reactive materials from begin landfilled, including placement in a hazardous waste landfill. By regulation, then, every Army site which contains explosive residues, which range from low parts per million up to fifty percent in the worst cases, would require treatment prior to final disposal. Since many sites with low levels of contamination are not expected to exhibit any explosive properties, identifying such sites would remove from them the requirement to treat the residues as reactive wastes. Therefore, tests are provided in this plan which are suitable for determining whether a contaminated soil or sediment is reactive due to explosivity according to Environmental Protection Agency definitions.

---

*Three sediment samples are obtained from each lagoon and analyzed for explosive concentration. One sample is taken near the waste water influent point, another near the effluent point, and the third sample is taken from the middle of the lagoon.

a. Of the eight characteristics defining a reactive waste in Ref. 2a, the characteristics pertaining to explosive wastes are:

   1. Capable of detonation or explosive reaction if subjected to a strong initiating source or if heated under confinement.

   2. Capable of detonation or explosive decomposition or reaction at standard temperature or pressure.

   3. Is a forbidden explosive as defined in 49 CFR 173.51 or a Class A or Class B explosive as defined in 49 CFR 173-53 and 88.

b. Ref. 2b defined tests for explosives which address the above definitions of reactivity as follows:

   1. A Stability Test is performed by heating the residue to 75°C for 48 hours. This test defines a forbidden explosive according to 49 CFR 173.51.

   2. A Detonation Test is performed by inserting a blasting cap into a sample and observing the detonation. Reaction of the sample to a strong initiating source and Class A explosives as defined in 49 CFR 173.53 are tested in this manner.

   3. A Spark Test is performed by inserting a time fuze or an electric squib into a sample and observing for deflagration or detonation. This tests for explosives as defined in 49 CFR 173.53 (initiating explosives) and 49 CFR 173.88 (propellants).

   4. An Impact Test is performed on the Bureau of Explosives Impact Apparatus to define Class A explosives according to 49 CFR 173.53.

c. In Ref. 2d, the above tests were discussed with Dr. H. Matsuguma of the Army's Primary Explosives Research Laboratory. Pertinent comments regarding the above tests were as follows:

   1. The tests are adequate for a go/no-go evaluation of reactivity, except that the results of the Impact Tests will be misleading at low explosive concentrations. Since impact testing is designed to be a severe test used for ranking reactions of various explosives. It is possible to eke out positive results even from minute quantities of explosives. Supplementing Impact Test results with a Card Gap Test, as outlined in Ref. 2c, will better define the ability of a contaminated sample to propagate detonation.

   2. Soil and sediment samples should be analyzed to determine the explosive constituents and their concentrations. However, the chemical analysis methods are not germane to the actual reactivity tests and are not addressed in this plan.

3. The Stability, Detonation, Impact, and Card Gap Tests are performed in a standard manner, although some minor modifications are required to accommodate preparation of environmental samples. The Spark Test is not a standard test for the Army, but with modification, can be performed in the same manner as the Detonation Test.

V. TEST EQUIPMENT AND MATERIALS

The following items are required to perform the necessary explosives tests on one field sample. Ancillary laboratory equipment is not included.

a. One Bureau of Explosives Impact Apparatus.

b. One ventilated explosion-proof oven equipped to continuously record temperature.

c. One blasting machine or equivalent.

d. Electric firing wire.

e. Electric blasting caps.

1. Five No. 8 electric blasting caps (contains 2 gms of 80/20 mixture mercury fulminate/potassium chlorate).

2. Three engineer special electric blasting caps.

f. Five electric match head igniters.

g. Two inch diameter by 1 inch long pressed pentolite pellet, National Stock No. 1375-00-991-8891, as required.

h. Solid lead cylinders 1-1/2 inch diameter by 4 inches high as required.

f. One piece of mild steel plate SAE 1010 to 1030, 1/2 inch thick by 12 inches square.

j. Mild steel plates (SAE 1010 to 1030) 6 x 6 inches x 3/8 inch as required.

k. Tubing, steel cold drawn seamless, mechanical, composition 1015, 1-7/8 inch 00, 0.219 inch wall thickness by 5-1/2 inch long, as required.

VI. SAMPLE PREPARATION:

A complete set of tests will require a five pound sample from each field sampling point. Samples will generally be received wet and possibly split into multiple containers for shipping purposes. The field sample will be prepared and split into laboratory samples as follows:

a. Recombine samples if necessary. Samples may be mixed while wet to achieve uniformity. Large chunks should be broken up, in a ball mill or mortar and pestle, using an operational shield if necessary.

b. The wet samples must be dried to the appropriate moisture content for testing.

1. The apropriate moisture content will be determined by taking a soil sample from a depth of four feet at a point close to the lagoon being sampled. That sample will then be weighed, dried in an oven until constant weight is achieved, and then reweighed. From this, the moisture content will be calculated.

2. For each soil or sediment sample to be tested for explosivity, a sub-sample will be drawn, weighed, oven dried, and then reweighed to determine its original moisture content. The amount of water weight which must be removed from each sample to reach the moisture content in 6b(1) above will then be calculated.

3. Each soil or sediment sample will then be weighed, spread in a thin layer on a tray, and then dried in an oven at 60°C until the amount of water weight calculated in 6b(2) above has been removed. The sample must be monitored and reweighed until the desired weight is reached.

c. Laboratory test samples will be prepared from the prepared field sample as follows:

1. For the Thermal Stability, Detonation, and Spark Tests, prepare a total of eleven samples by filling a four-ounce paper cup approximately 2/3 full. The sample should not contain large chunks and should be tamped as it is filled to insure continuity of the sample.

2. For the Impact Sensitivity Test, withdraw an approximate 200 mg sample from the field sample. This sample must then be carefully crushed so that 10 mg of uniformly fine consistency can be drawn from it. Description of the individual samples is incorporated under the Impact Sensitivity Test.

3. For the Card Gap Test, prepare three samples by filling the tubes listed in para. 5k with the material to be tested. Insure that the sample is continuous by tamping. If the consistency of the sample is such that it will not consolidate, a piece of light cellophane tape may be placed across the lower end to retain the sample.

VII. TEST METHODS

Although it could be argued that some of these tests are not applicable to certain pure explosives, it is possible to encounter residues from mixed explosives or environmentally altered residues which will not behave in the classic manner. Therefore, the complete series of tests will be performed on each sample. Test results will be recorded on a data sheet similar to Fig. 1. Tests may be run in any convenient order.

a. Thermal Stability. Place one sample from para. 6d(1) in a constant temperature explosion-proof oven. Raise temperature of the oven to 75°C and maintain at 75°C for 48 consecutive hours. Temperatures will be continuously recorded. Constant observation is not required. Record results on data sheet.

b. Spark Test. Place a lead block (para. 5h) on the steel plate (para. 5i). Using a sample from para. 6d(1), make a small depression in the sample with stick or pencil, insert an electric match head igniter (para. 5f) into the depression and secure (tape) the igniter wires to the cup for stability. Place the cup on the lead block, connect the firing circuit, and remotely initiate. Deflagration will be evidenced by the energetic burning of the sample. Detonation of the sample will cause mushrooming of the lead block. Repeat the test five times or until evidence of a deflagration or detonation occurs, whichever is less. Record results on data sheet.

c. Detonation Test. Place a lead block (para. 5h) on the steel plate (para. 5i). Using a sample from para. 6d(1), press a hole about half the length of the blasting cap into the center of the sample using a pencil, then insert a No. 8 blasting cap into the sample. A wood block with a hole drilled in it similar to Fig. 2 may be used to support the blasting cap. Place the sample onto the lead block, connect the firing circuit, and remotely initiate. Detonation of the sample will cause mushrooming of the lead block. Repeat the test five times or until detonation occurs, whichever is less. Record results on a data sheet.

d. Impact Sensitivity Test: Conduct ten individual tests using one sample (para. 6d(2)) per test in the Bureau of Explosives Impact Apparatus. Place a 10 mg sample in the cup assembly. Drop the weight from the maximum height of the machine. Observe the result and record on the data sheet. Conduct tests at an ambient temperature of 25°C 5°C. Insure cup and anvil are thoroughly cleaned and dried between test runs.

e. Gap Test

1. Assemble the following items for each test to be conducted:

   a. One sample prepared according to para. 6d(3).

   b. Two pentolite pellets (para. 5g).

   c. One engineer's special electric blasting cap, J2 (para. 5e(2)).

   d. Blasting machine and firing wire (para 5c. and d).

   e. One 5 x 6 inch steel plate (para. 5j).

   f. Plastic material, 1/16 inch thick cut into 1/2 inch squares.

2. Arrange the materials as shown in Fig. 2. The witness plate is supported on two edges, about 6 inches above ground surface. The small plastic squares are placed on the plate to support the pipe and maintain a 1/16 inch air gap. The squares should be under the edge of the pipe, rather than under the explosive. The pentolite boosters are then placed on top of the sample as shown in Fig. 2, except that the gap cards and the cardboard tube are not used. The blasting cap is then placed on top of the pentolite (with a wood support ring) and remotely detonated. Detonation of the sample is indicated when a clean hole is cut in the witness plate. This test is performed three times or until a detonation occurs, whichever is less. Results are recorded on the data sheet.

VIII. INTERPRETATION OF RESULTS

For the purpose of reactivity evaluation, a positive result from any single test will indicate that a given field sample is reactive, except that results from the Impact and Gap Tests should be considered together.

a. A sample is considered reactive due to instability if it detonates, deflagrates, or decomposes exothermically (as evidenced by a rise in temperature on the recorder) during the Thermal Stability Test.

b. The field sample is considered to be reactive if one lab sample detonates, deflagrates, or burns in a sustained flame during the Spark Test. Localized smoldering does not indicate reactivity.

c. The field sample is reactive if one sample detonates during the detonation test.

d. The Impact Sensitivity Test may be considered positive if detonation (explosion, flame, noise) occurs in at least 50 percent of the ten tests. Conversely, if detonation does not occur in at least 50 percent of the tests, the sample is non-reactive. However, the results of the Impact Sensitivity Test are the most difficult to interpret, since samples can exhibit partial response under such harsh treatment. In such cases, the Gap Test should be used as a discriminator, defining a material as reactive if it detonates once out of three tests.

IX. CONCLUSION

The tests conducted under this plan exceed minimum requirements for determining reactivity due to explosive properties as specified in Ref. 2b. The Thermal Stability, Spark, and Detonation Tests are performed as specified. The Impact Sensitivity Test is performed in a manner more stringent than specified to insure that results are safe-sided. Since Impact Sensitivity Tests may present results which are difficult to interpret, the Shock or Gap Test has been added as a discriminator to determine whether a questionable material is detonable under worst-case conditions. It can be stated with certainty that a sample which does not respond positively to these tests is not reactive due to explosive properties as defined in Ref. 2a.

SW 84B, DATED MAY 1980
"TEST METHODS FOR EVALUATING SOLID WASTE"

SUBSECTION 6.2

DEFINITION OF EXPLOSIVE MATERIALS

For purposes of this regulation, a waste which is a reactive waste by reason of explosivity is one which meets one or more of the following descriptions:

1. Is explosive and ignites spontaneously or undergoes marked decomposition when subjected for 48 consecutive hours to a temperature of 75°C (167°F).

2. Firecrackers, flash crackers, salutes, or similar commercial devices which produce or are intended to produce an audible effect, the explosive content of which exceeds 12 grains each in weight, and pest control bombs, the explosive content of which exceeds 18 grains each in weight; and any such devices, without respect to explosive content, which on functioning are liable to project or disperse metal, glass or brittle plastic fragments.

3. Fireworks that combine an explosive and a detonator or blasting cap.

4. Fireworks containing an ammonium salt and a chlorate.

5. Fireworks containing yellow or white phosphorus.

6. Fireworks or fireworks compositions that ignite spontaneously or undergo marked decomposition when subjected for 48 consecutive hours to a temperature of 75°C (167°F).

7. Toy torpedoes, the maximum outside dimension of which exceeds 7/8 inch, or toy torpedoes containing a mixture of potassium chlorate, black antimony and sulfur with an average weight of explosive composition in each torpedo exceeding four grains.

8. Toy torpedoes containing a cap composed of a mixture of red phosphorus and potassium chlorate exceeding an average of one-half (0.5) grain per cap.

9. Fireworks containing copper sulfate and a chlorate.

10. Solid materials which can be caused to deflagrate by contact with sparks or flame such as produced by safety fuse or an electric squib, but can not be detonated (see Note 1) by means of a No. 8 test blasting cap (see Note 2). Example: Black powder and low explosives.

11. Solid materials which contain a liquid ingredient, and which, when unconfined (see Note 3), can be detonated by means of a No. 8 test blasting cap (see Note 2); or which can be exploded in at least 50 percent of the trials in the Bureau of Explosives' Impact Apparatus (see Note 4) under a drop of 4 inches or more, but can not be exploded in more than 50 percent of the trials under a drop of less than 4 inches. Example: High explosives, commercial dynamite containing a liquid explosive ingredient, primarily nitroglycerin component.

12. Solid materials which contain no liquid ingredient and which can be detonated, when unconfined (see Note 3), by means of No. 8 test blasting cap (see Note 2); or which can be exploded in at least 50 percent of the trials in the Bureau of Explosives' Impact Apparatus (see Note 4) under a drop of 4 inches or more, but can not be exploded in more than 50 percent of the trials under a drop of less than 4 inches. Example: High explosives, commercial dynamite containing no liquid explosive ingredient, trinitrotoluene, amatol, tetryl, picric acid, ureanitrate, pentolite, commercial boosters.

13. Solid materials which can be caused to detonate when unconfined (see Note 3), by contact with sparks or flame such as produced by safety fuse or an electric squib; or which can be exploded in the Bureau of Explosives' Impact Apparatus (see Note 4), in more than 50 percent of the trials under a drop of less than 4 inches. Example: Initiating and priming explosives, lead azide, fulminate of mercury, high explosives.

14. Liquids which may be detonated separately or when absorbed in sterile absorbent cotton, by a No. 8 test blasting cap (see Note 2); but which can not be exploded in the Bureau of Explosives' Impact Apparatus (see Note 4), by a drop of less than 10 inches. The liquid must not be significantly more volatile than nitroglycerine and must not freeze at temperatures above minus 10°F. Example: High explosives, desensitized nitroglycerine.

15. Liquids that can be exploded in the Bureau of Explosives' Impact Apparatus (see Note 4) under a drop of less than 10 inches. Example: Nitroglycerine.

16. Blasting caps. These are small tubes, usually made of an alloy of either copper or aluminum, or of molded plastic closed at one end and loaded with a charge of initiating or priming explosives. Blasting caps (see Note 5) which have been provided with a means for firing by an electric current, and sealed, are known as electric blasting caps.

17. Detonating primers which contain a detonator and an additional charge of explosives, all assembled in a suitable envelope.

18. Detonating fuses, which are used in the military service to detonate the high explosive bursting charges of projectiles, mines, bombs, torpedoes, and grenades. In addition to a powerful detonator, they may contain several ounces of a high explosive, such a tetryl or dry nitrocellulose, all assembled in a heavy steel envelope. They may also contain a small amount of radioactive component. Those that will not cause functioning of other fuses, explosives, or explosive devices in the same or adjacent containers are classed as Class C explosives and are not reactive waste.

19. A shaped charge, consisting of a plastic paper or other suitable container comprising a charge of not to exceed 8 ounces of a high explosive containing no liquid explosive ingredient and with a hollowed-out portion (cavity) lined with a rigid material.

20. Ammunition or explosive projectiles, either fixed, semi-fixed or separate components which are made for use in cannon, mortar, howitzer, recoilless rifle, rocket, or other launching device with a caliber of 20mm or larger.

21. Grenades. Grenades, hand or rifle, are small metal or other containers designed to be thrown by hand or projected from a rifle. They are filled with an explosive or a liquid, gas, or solid material such as a tear gas or an incendiary or smoke producing material and a bursting charge.

22. Explosive bombs. Explosive bombs are metal or other containers filled with explosives. They are used in warfare and include airplane bombs and depth bombs.

23. Explosive mines. Explosive mines are metal or composition containers filled with a high explosive.

24. Explosive torpedoes. Explosive torpedoes, such as those used in warfare, are metal devices containing a means of propulsion and a quantity of high explosives.

25. Rocket ammunition. Rocket ammunition (including guided missiles) is ammunition designed for launching from a tube, launcher, rails, trough, or other launching device, in which the propellant material is a solid propellant explosive. It consists of an igniter, rocket motor, and projectile (warhead) either fused or unfused, containing high explosives or chemicals.

26. Chemical ammunition. Chemical ammunition used in warfare is all kinds of explosive chemical projectiles, shells, bombs, grenades, etc., loaded with tear, or other gas, smoke or incendiary agent, also such miscellaneous apparatus as cloud-gas cylinders, smoke generators, etc., that may be utilized to project chemicals.

27. Boosters, bursters, and supplementary charges. Boosters and supplementary charges consist of a casing containing a high explosive and are used to increase the intensity of explosion of the detonator of a detonating fuse. Bursters consist of a casing containing a high explosive and are used to rupture a projectile or bomb to permit release of its contents.

28. Jet thrust units or other rocket motors containing a mixture of chemicals capable of burning rapidly and producing considerable pressure.

29. Propellant mixtures (i.e., and chemical mixtures which are designed to function by rapid combustion with little or no smoke).

Note 1: The detonation test is performed by placing the sample in an open-end fiber tube which is set on the end of a lead block approximately 1-1/2 inches in diameter and 4 inches high which, in turn, is placed on a solid base. A steel plate may be placed between the fiber tube and the lead block.

Note 2: A No. 8 test blasting cap is one containing two grams of a mixture of 80 percent mercury fulminate and 20 percent potassium chlorate, or a cap of equivalent strength.

Note 3: "Unconfined" as used in this section does not exclude the use of a paper or soft fiber tube wrapping to facilitate tests.

Note 4: The Bureau of Explosives' Impact Apparatus is a testing device designed so that a guided 8-pound weight may be dropped from predetermined heights so as to impact specific quantities of liquid or solid materials under fixed conditions. Detailed prints may be obtained from the Bureau of Explosives, 2 Pennsylvania Plaza, New York, New York 10001.

Note 5: Blasting caps, blasting caps with safety fuse, or electric blasting caps in quantities of 1,000 or less are classified as Class 0 explosives and not subject to regulation as a reactive waste.

REACTIVITY/EXPLOSIVITY TEST DATA SHEET

Installation ____

Sample Number and Location ______________________________

Explosive Components and Concentrations _________________

Test Result: Sample is Reactive/Non-Reactive (circle one) ____________________

Detonation Test

	Exploded Yes	Exploded No	Deflagration Yes	Deflagration No
No. 8 Blasting Cap Test I	____	____	____	____
Test II	____	____	____	____
Test III	____	____	____	____
Test IV	____	____	____	____
Test V	____	____	____	____

Samples: Five 4 oz. cups

Test: One blasting cap per sample.

Spark Test

	Exploded Yes	Exploded No	Burned Yes	Burned No
Electric Match Head Igniter	____	____	____	____
Test I	____	____	____	____
Test II	____	____	____	____
Test III	____	____	____	____
Test IV	____	____	____	____
Test V	____	____	____	____

Samples: Five 4 oz. cups

Thermal Stability Test

Explosion Yes	Explosion No	Ignition Yes	Ignition No	Marked Decomposition Yes	Marked Decomposition No
____	____	____	____	____	____

Samples: One 4 oz. cups

Test: 48 hours at 75°C in vented oven.

Card Gap Test Samples: 3 Tubes Detonation: Yes ____ No ____

Impact Sensitivity Test

Bureau of Explosives Impact Apparatus

Maximum Height Drop Test
10 Trials

No. of Trials Exhibiting

Explosion Flame and Noise	No Explosion No Flame No noise

Approved:

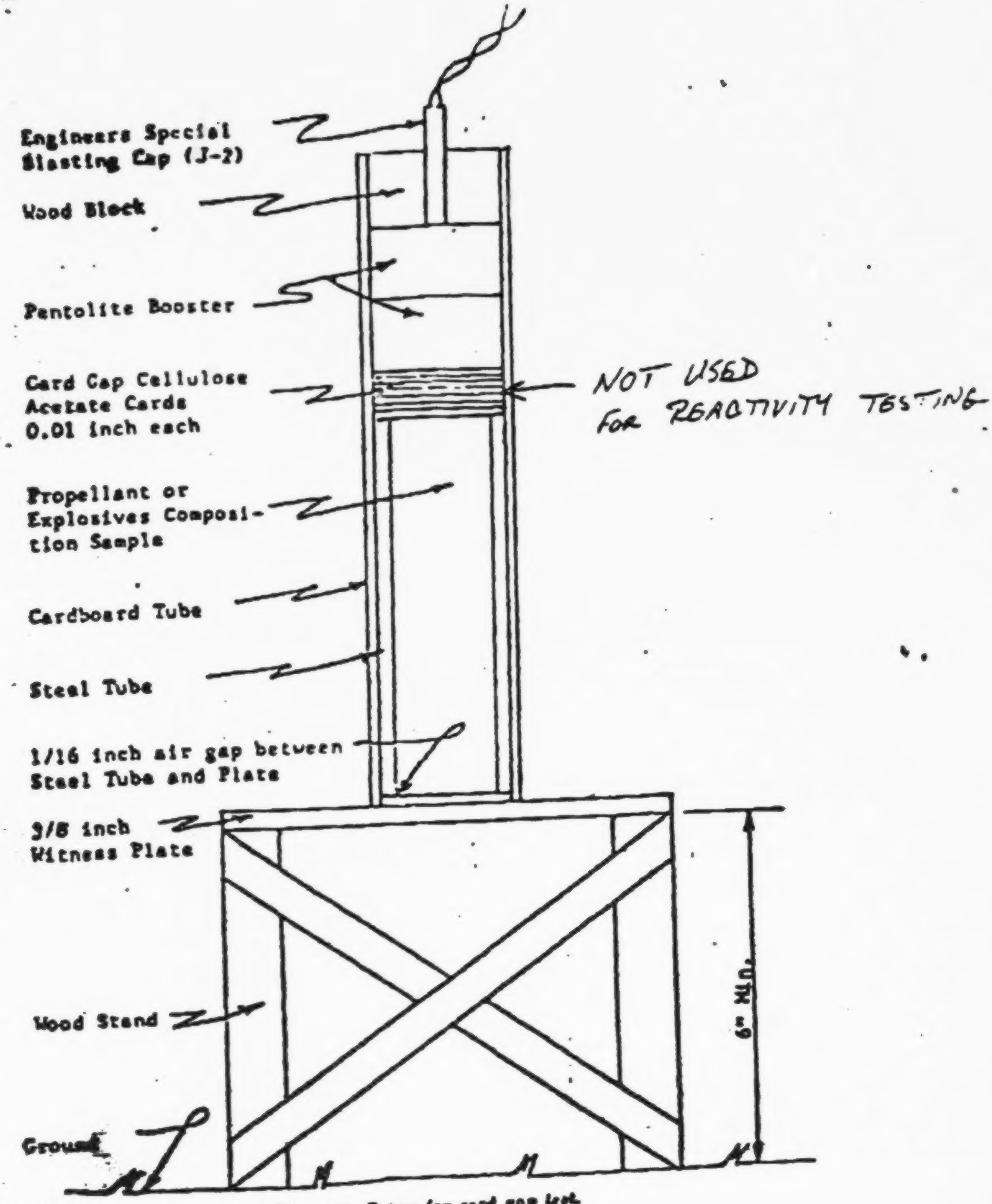
Test Director ______________________

Test Department Head ________________

Signature ______________________

Title ______________________

Organization ______________________


Engineers Special Blasting Cap (J-2)
Wood Block
Pentolite Booster
Card Gap Cellulose Acetate Cards 0.01 inch each
Propellant or Explosives Composition Sample
Cardboard Tube
Steel Tube
1/16 inch air gap between Steel Tube and Plate
3/8 inch Witness Plate
Wood Stand
Ground
6" MIN.

NOT USED FOR REACTIVITY TESTING

Figure 2. Setup for card gap test.